ELECTRICAL ENGINEERING

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The Cover: At New York's LaGuardia Airport, a 2,500-watt short-arc mercury lamp developed by Westinghouse sends skyward a beacon that directs departing airplanes toward a more sparsely settled take-off route (see "Of Current Interest," page 626).

Utility Engineering—Problems and Opportunities ..... Philip Sporn 559
The Need for a National Science Policy ..... J. E. Hobson 563
Classified Bibliography on Insulated Conductors ..... L. F. Hickernell 567
A Multistable Transistor Circuit ..... R. A. Henle 570
Impulse Tests on Low-Voltage Windings of Distribution Transformers ..... J. E. Holcomb 573
Dielectric Behavior of Some Fluorogases and Their Mixtures With Nitrogen ..... G. Camilli, T. W. Liao, R. E. Plump 580
Switching of Substation Capacitor Banks by Current-Biased Induction-Voltage Relay ..... W. C. Osteen, J. J. McCullough 586
Transistor Demodulator for Magnetic Amplifiers in A-C Servo Applications ..... R. O. Decker 590
Radiation Counter for Beta Particles ..... D. T. Williams 595
Basic Problems in Film Pickup for TV Broadcasting ..... E. M. Gore 600

JULY 1955

EASTMAN KODAK CO. RESEARCH LIBRARY DIVISION PHYSICS

TECHNICAL PAPER DIGESTS

A 69-Kv Compressed-Air Circuit Breaker ..... R. E. Kane, J. K. Walker 578
Intermittently Increased Kilovar Output ..... P. M. Minder 579
Compressional Stress on Magnetic Laminations ..... R. E. Fischell 585
European Practices in Power-Line Design ..... Eduard Fritz 589
Noncontacting Vibration Pickups ..... H. F. Clarke 593
Solid-Core High-Voltage Bushings ..... H. H. Brustle, D. L. Johnston, A. L. Scheideler 594
Circuit Breakers for Switching 230-Kv Lines ..... D. M. Umphrey, D. J. Marsden 599
A Test Board for Watt-Hour Meter Standards ..... F. J. Levitsky 605
Analysis of Errors in Sampled-Data Systems ..... Jack Sklansky, J. R. Ragazzini 606
Erection of Vertical Water-Wheel Generators ..... W. D. Houser, W. Hindle, J. A. Tyerman 607

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MISCELLANEOUS SHORT ITEMS: Pump Performance Studied, 562; New Mobile Substation, 566; Electric Heater Increases Oil-Well Production, 584; Cathode-Ray Analyzer to Aid Auto Repair, 588; Two Major Airlines Add Selective-Calling Radios, 592; 5-Cycle Distribution Power Circuit Breaker, 598; World's Fastest Operatorless Elevators, 604

Institute Activities 608
AIEE Fellows Elected, 618; AIEE Personalities, 621; Obituaries, 624

Of Current Interest 625
Letters to the Editor, 634; New Books, 635; Pamphlets, 638

Industrial Notes 14A
New Products, 30A; Trade Literature, 44A

Index to Advertisers 70A

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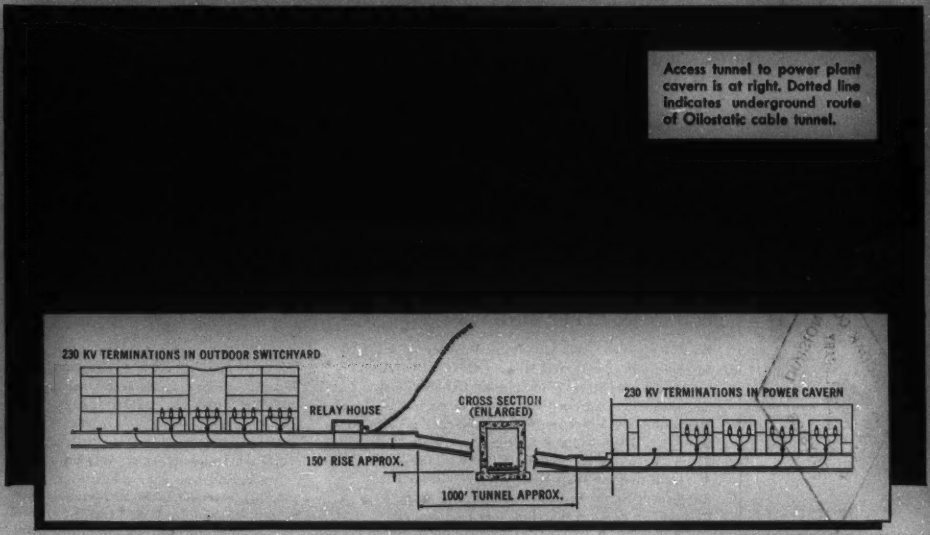
ANOTHER OKONITE FIRST:

the first American-built 230 kv Oilostatic high-pressure oil, pipe-type cable system


Access tunnel to power plant cavern is at right. Dotted line indicates underground route of Oilostatic cable tunnel.
230 KV TERMINATIONS IN OUTDOOR SWITCHYARD
RELAY HOUSE
CROSS SECTION (ENLARGED)
230 KV TERMINATIONS IN POWER CAVERN
150' RISE APPROX.
1000' TUNNEL APPROX.

Schematic Cross-Section of 230 kv Oilostatic Cable System Cubatao Underground Station, Sao Paulo, Brazil.

Okonite's leadership in the development of high-tension cables is again demonstrated by the manufacture of a 230 kv Oilostatic cable—the first American-built 230 kv high-pressure, pipe-type cable system. This cable, recently shipped, was ordered in March, 1951, for installation at the Cubatao Underground Power Plant of the Sao Paulo Light and Power Company Limited, Sao Paulo, Brazil.

The underground power plant, utilizing a hydrostatic head of 2,300 feet, is located in a cavern 600 feet inside a mountain. Four Oilostatic circuits of single conductor, 500 MCM, 0.835-inch paper-insulated, shielded, D-shaped copper wire armored cables will carry the output of the four 65,000 kw generators being installed. A separate tunnel from the power plant to the switchyard is provided for the cable circuits and the control cables.

Oilostatic high-pressure oil, pipe-type systems are self-supervising, easy to install and require negligible maintenance. For complete installation and operation information, write to The Okonite Company, Passaic, N. J.

Available with either copper or aluminum conductors

OKONITE insulated cables

3591

HIGHLIGHTS.....

Summer Meeting. As this issue is being distributed many of our members and their guests are enjoying attendance at the 1955 Summer General Meeting in Swampscott, Mass. In addition to all the recreational facilities offered by the meeting hotel, the New Ocean House, and the historical interest of the surrounding area, the more serious aspects of the meeting are being well taken care of by an extensive and diversified technical program and a number of inspection trips of both technical and general interest.

Coming Meetings. Plans for the Institute's Pacific General Meeting, to be held August 15–18 in Butte, Mont., are being formulated. Some 18 technical sessions are being featured, as well as inspection trips to Anaconda's smelter and Kelly Mine (*p. 610*). Other forthcoming meetings include the Petroleum Technical Conference in Houston, Tex., and the Instrument Conference in Los Angeles.

Middle Eastern District. AIEE's Columbus Section entertained some 703 persons at the Middle Eastern District Meeting in May. Twenty-one technical sessions were held, in addition to the General Session and an all-day session for students. Highlight of the program for the ladies was tea at the Governor's Mansion (*pp. 608–10*).

Fellows Elected. Short biographies of seven men recently elected to the grade of Fellow in the Institute are included in this issue. Among these are B. G. Ballard of Canada's National Research Council and Westinghouse's Roy L. Brown (*pp. 618–21*).

Switching of Substation Capacitor Banks. A control scheme that utilizes a conventional single-phase voltage relay, modified by the addition of a current winding or dropping resistor, has been developed for automatically switching large banks of substation static capacitors as a unit, for the purpose of voltage control and power factor correction (*pp. 586–8*).

Transistor Demodulator for Magnetic Amplifiers. The transistor demodulator described in this article is a stable detector and demodulator which can operate at signal voltage levels as low as 20 millivolts and as high as 30 volts rms with low drift in the range from −65 to +75 C. It is suitable for use in a synchro-controlled system as it can be combined with a stable full-wave magnetic amplifier (*pp. 590–2*).

Insulated Conductor Bibliography. The AIEE Committee on Insulated Conductors in 1949 began the compilation of a bibliography which was published in 1954. Since the technique evolved by the committee is innovational and may be adapted to other subjects, a description of this particular attempt to methodize reference material is published to encourage other technical committees to undertake similar projects (*pp. 567–9*).

Need for a National Science Policy. Free enterprise, the American system, is best described in terms of productivity; and productivity is the sum of new knowledge, new techniques, new skills. In turn, it is research which creates these new techniques and skills, and if an atmosphere conducive to research is to be maintained in the United States, then there is need for a national science policy to preserve and strengthen our democratic institutions (*pp. 563–6*).

A Multistable Transistor Circuit. This article describes a method of multistable operation which requires only two active elements for any number of statically stable states. This provides an economical application of transistors to counter circuits (*pp. 570–2*).

Radiation Counter for Beta Particles. A cadmium-sulfate crystal mounted in a hypodermic needle provides a small practical conduction-type radiation counter. It offers many advantages over counters of this type (*pp. 595–8*)

Impulse Tests on the Low-Voltage Windings of Distribution Transformers. These tests are considered in terms of fault detection, transient behavior of distribution transformers, and transients to which the transformer may be subject in service. An impulse test is described which properly stresses both the high- and low-voltage windings of the smaller distribution transformers (*pp. 573–7*).

Utility Engineering—Its Problems and Opportunities. The way utility engineering is misleadingly underestimated and the economic significance of the electrical utility industry are pointed out. The importance and challenge of the present and future problems in electrical engineering utility are ably demonstrated (*pp. 559–62*).

Dielectric Behavior of Certain Fluorogases and Their Mixtures With Nitrogen. The test setup and procedure are presented together with a discussion of the dielectric strength of pure fluorogases and with nitrogen added, and the impulse strength of fluorogas-nitrogen mixtures, and additional advantages of such admixtures are given in the conclusions (*pp. 580–4*).

Basic Problems in Film Pickup for TV Broadcasting. Many important problems of television film reproduction are treated in terms of film characteristics, film camera types and television projectors, the quality characteristics of film cameras, other elements of the film reproducing system, corrective devices and methods, a Vidicon color-film camera system, and conclusions (*pp. 600–04*).

News Index

Institute Activities 608
- Middle Eastern District Meeting Held 608
- Pacific General Meeting 610
- District 1 Student Prizes 610
- Publicity for Research 611
- Future AIEE Meetings 611
- Second Petroleum Industry Conference 612
- AIEE Fellows Elected 618
- AIEE Personalties 621
- Obituaries 624
- Membership 624

Of Current Interest 625
- Dual-Cycle Boiling Reactor 625
- Skyway Traffic Light 626
- Electronic Stethoscope 627
- Future Meetings of Other Societies 628
- Letters to the Editor 634
- New Books 635
- Pamphlets 638

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

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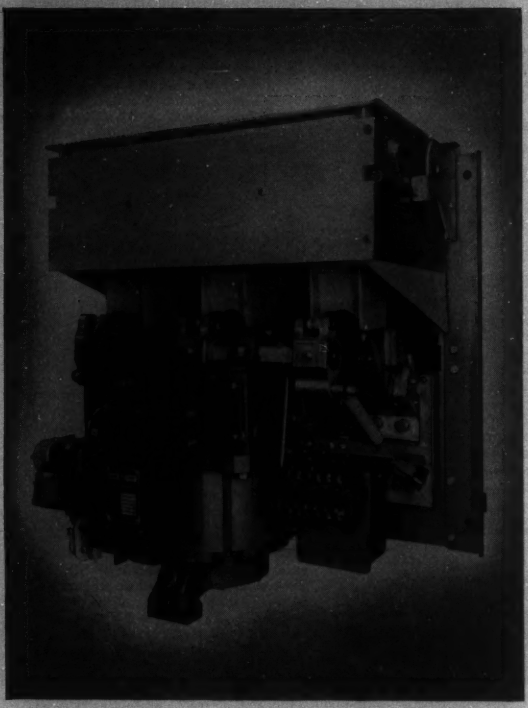
News of new developments in



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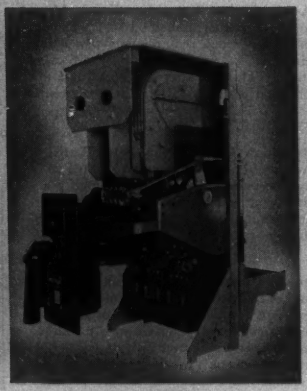
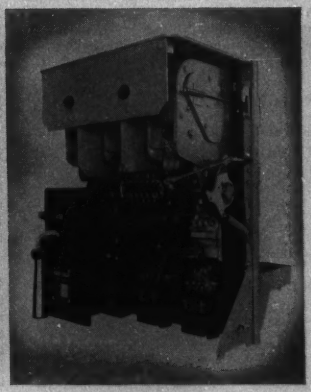
KA Circuit Breaker



KB Circuit Breaker



KC Circuit Breaker

UTILITY ENGINEERING
Problems and Opportunities

PHILIP SPORN
FELLOW AIEE

The arguments aimed at ambitious young engineers to convince them that electrical utility engineering has little to offer are examined and shown to lack solid factual support. However, considerable evidence is presented showing the economic significance of the electrical utility industry and the wide variety of challenging problems and opportunities it poses.

THERE IS A PREVAILING NOTION, particularly prevalent among engineering students and young engineers just embarking on their careers, that electrical utility engineering is of no great significance; or if it is, that it offers very little excitement or opportunity to a serious, able, and ambitious young engineer for productive work and for growth and development. Utility engineering here means engineering as carried out by the many electrical utility organizations. While some of these are very large, a great many are much smaller; and yet their lack of size does not give them any exemption from having to contend with the many problems, or a good many of the problems, with which the larger organizations have to deal.

The general line of reasoning behind this putative state of affairs in utility engineering is a 4-forked one. First, there is the altogether too common notion that there are no real problems of any size, complexity, or significance in utility engineering. Indicative of that state of mind is the opinion publicly expressed some years ago by one engineer and government administrator, very prominent nationally, that electrical utility systems are fundamentally much simpler than a shoe business. Again, it is frequently stated that, if any problems did exist, they were all solved a long time ago, so that all there is to do today is to go to a report or a bookshelf and take down the solution just as one would take down a package of carriage bolts. If this does not satisfy an insistent or persistent inquirer, he is informed that, "Well, all new engineering, if any has to be done, is done by the electrical and mechanical and other manufacturers anyhow." Thus, obviously, no engineering remains to be performed by any members of a utility engineering organization. Finally, if this last argument does not stand up, one is always confronted with the statement, "You will have to admit whatever utility engineering there is to be done is much too prosaic: certainly there is no excitement in doing it." In other words, it has—to use a much-abused phrase—no "glamour."

This is so formidable a line of argument that it would be particularly impressive if the facts were available to make it good. Unfortunately, or perhaps fortunately, the facts are not so at all and therefore, the argument, ingenious as it is, simply falls down for lack of any solid factual basis of support.

One of the reasons, perhaps, why such bad thinking is common on the utility engineering problem is the failure to appreciate the economic significance of the operation of the electrical utility systems of the country. It was not so long ago that the steam railroads were the basic industry of the United States. Yet, with a much later and much slower start, the electrical utilities of the country pulled up to the railroads in plant investment in 1952 when the figures for both reached an approximate value of

Full text of an address presented before the General Session of the AIEE Middle Eastern District Meeting, Columbus, Ohio, May 4–6, 1955.

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$25 billion. Since then, electrical utility investment has pulled far ahead of the railroads.

Even more significant in this connection is an examination of the investment of the electric power industry relative to some of the other basic industries, a number of them being, admittedly, in the more "glamourous" category. When one compares the investment figures in these for the year 1953, for example, against the investment in the power industry one finds:

Industry	Per Cent
Chemical and allied products	less than 60
Aircraft	about 11.5
Electronics	about 13.5

If the electric power industry investment for 1953 is examined and compared with that in all manufacturing corporations' facilities over all of the United States, the electric power investment is found to be close to 15 per cent of the total. Even more striking is this fact: The total investment expenditures made in 1952 in electric power facilities were about 22.5 per cent of the total investment expenditures in plants and equipment of all manufacturing corporations in the United States, and in 1953 the figure rose to 23.5 per cent.

If anything further were needed in the way of statistics to bring out sharply the great and deep economic significance of the electrical utilities to the economy of the United States, it is this: At the end of 1954, after approximately 75 years of growth and development of the electrical utility industry, total investment in their facilities reached a figure close to $30 billion. Competent and serious students of the indicated developments that are ahead in the field of power, all more or less agree that there is good reason for the conclusion that some time within the next 20 to 25 years the utility systems' facilities will have to be approximately quadrupled, and the investment will go up in about the same ratio.

Starting from an investment base of $30 billion, it is obvious that in this period it will be necessary to bring about a net additional investment of some $90 billion; the gross investment will obviously be considerably greater.

It would thus appear from the foregoing data that the question of economic significance of the electrical utility industry today cannot be a matter of argument, and that perhaps there is very good reason for the belief that as time goes on the industry may become the most important single industry in the United States. It will command such a position, perhaps, not so much on the basis of value of annual product, but particularly on the score of capital investment, and on the basis of the fundamental pervasive character of electric power and the complete involvement that electric power is going to have, to a much greater extent in the future than even today, in every phase of activity and living in the United States.

WHAT ELECTRICAL UTILITY ENGINEERING INVOLVES

WHAT IS UTILITY SYSTEMS ENGINEERING and how does it differ from the engineering carried out by the manufacturers? It is quite clear that the manufacturers' responsibility is to design and build equipment or parts of equipment utilized in building utility systems. Utilities engineering is concerned with planning, building, operating, and maintaining the utility systems which are, in turn, composed of numerous components—many of them built by manufacturers, but a great many others put together by the utilities themselves out of essential raw materials like steel, concrete, pipe, conductor, etc. There is, however, this limitation: that whereas the manufacturers frequently do the conceiving and the designing, and almost always do the building of the equipment, they are in no position to know what to plan to build, or what to plan to develop, until the utilities system engineers have done their part and have indicated what it is that they will need or want. The latter is the function of the utility engineer. The proper carrying out of that function by the utility engineer involves study and planning of his power system. And that involves a constant study and understanding of short- and long-term political and economical developments both national and international; study of population growth and population shifts; study and understanding of social, economic, and ecologic factors of various areas; thorough knowledge of the industries basic to each area or region served and of the possibilities of promoting growth and development of the existent industries and of the establishment of new industries.

Indispensable to the planning of any power system is a basic study of fuel supply: white coal, fossil fuels, and, almost in the offing, nuclear fuels—their availability, their transportation, and their purchase on short- and long-term arrangements.

OPPORTUNITIES IN UTILITIES ENGINEERING

THE STUDY AND PLANNING of the system proper starts with the power plant and carries on through the transmission system, gets down to the distribution facilities, and ends up with the utilization system. This is a big undertaking.

In the study and development of generation itself: What fuel resources to employ? How and where to build power plants? What size plants to build? What size units to build? What kind of thermodynamic cycle to employ, and more particularly what temperature, pressure, superheat, reheat to use? What voltage to employ as a generating voltage? How to give physical embodiment to the plant? What basic plan of construction? How excavate? How found? How control river rise and fall and abnormal rise? To answer all of these questions properly involves almost all phases of engineering, and calls for the solution of many problems of great difficulty and complexity.

Similarly there are many difficult engineering problems in transmission: The planning of the transmission system itself—how and where to build the lines? What voltage to employ? What form to give structures, whether single or double, or multicircuit type? How to tie transmission systems into subtransmission and distribution systems? How most effectively to utilize each to its economic limit? All of these individually and—even more so—collectively are difficult problems.

The problems encountered in utilization and in distribution are not less numerous, bothersome, and important. In utilization—in the field of electric energy as in no other

item of economic use—consumption has to take place before manufacture, and consumption can only take place through the utilization medium. Thus, the utilization medium and the associated system of wiring are indispensable elements in any kind of electric power operation. In the distribution field, it is significant that of all the elements involved in the basic power supply chain outside of utilization—generation, transmission, and distribution—distribution is by far the most expensive of the three and takes the largest investment of the three. Here, therefore, are the greatest opportunities and perhaps the greatest difficulties. And the field is almost entirely the utility engineer's.

Thus, whether examined from the standpoint of economic significance or economic value or from the standpoint of the allocation of problems between the manufacturing and the utility system engineering organization, there would seem to be no question that opportunities of every kind and variety and of unlimited scope are available to the engineer, if the qualified judgment of the extent of growth and development that lies ahead for the electrical utilities is accepted.

ECONOMIC INDEX OF OPPORTUNITIES AVAILABLE

PERHAPS THE FOLLOWING SIMPLE ARITHMETICAL EXAMPLE will bring home the importance of, and opportunities in, engineering and in development of economic usefulness of new engineering ideas in the field of electric power supply. A number, perhaps more than a half dozen, electrical utility systems are today approaching the point of annual output of close to 20 billion kwhr, and the prospect of these values growing not to 4 times the present values, but to a more moderate figure of $2^1/_2$ times, is extremely bright, and in a relatively short period—something of the order of 12 to 15 years. With a system having an input of 50 billion kwhr per year, a saving in generation, that is, an improvement in efficiency of heat conversion, of only 100 Btu per kilowatt hour represents an annual value of $1 million with fuel at 20 cents per million Btu and $1.5 million with fuel at 30 cents per million Btu. In this same kind of system, a saving in costs other than fuel of only 0.01 mil per kilowatt-hour represents an annual value of $500,000 and a saving of 0.1 mil per kilowatt-hour represents the staggering annual value of $5 million. Certainly, where economic prizes of that sort are available, the attractiveness of the effort to bring about such an economic gain would appear to be almost irresistible.

SPECIFIC EXAMPLES OF OPPORTUNITIES

IT MUST BE ADMITTED that some of the discussions given previously are perhaps on the general side, and it may very well be that there is reason for skepticism as to whether solid and substantial opportunities exist in the field of utility engineering, when the problem is restated on a more specific basis. There is some point, therefore, to expanding the discussion of the problems on a more specific plane. If one attempts to do that, one of the first things one is confronted with is an assumption as to the kind of electric power system one visualizes for the future.

The discussions presented alluded to the informed judgment that a quadrupling of present capacities and, therefore, electric energy generated and distributed over or within the relatively short interval of 20 to 25 years is a reasonable expectation. A discussion of specific problems to be encountered can, therefore, be carried out best against a background of 2,000 billion kwhr as the annual utility production some 25 years hence. Just fixing that point makes possible a reasonably realistic examination of the many elements of the power supply problem that will confront the planners and builders of the power system in the United States and the engineers of the electrical utility systems. And this begins to show not only what is already known, but perhaps what is lacking and, therefore, where the opportunity lies—by research, by inventiveness, to solve and thus help bring into being these very much larger power systems of the future.

When the power systems of the future are examined against this background, one of the first conclusions that one is forced to is that fundamentally the American power systems of that time will, to a large extent, continue to be powered by conventional or fossil fuel-burning stations. Furthermore, there is today every indication that coal will have to carry an increasingly greater share of the burden as the availability of gas and oil declines. The problems of mining and transporting the tremendous quantity of coal which will be required for electric generation alone—a figure which 25 years from now will be perhaps 25 per cent greater than the entire output of coal in the United States in 1954—certainly will require a great deal of thought and effort to solve. Underground gasification and increased mechanization in the mines are but two avenues of approach. But of particular importance to electrical utility engineers will be the problems created by wastes which may be released to the atmosphere as a result of burning large amounts of coal in concentrated areas. This problem itself has two aspects: meteorological, relating to dispersion of the gases and fine-particulate products of combustion; and chemical, relating to the toxicity of the wastes themselves.

Now, what about atomic power? Although it will be some time before nuclear fuel will be economically competitive with coal as a primary energy source—and this is particularly true since a nuclear technology cannot be built up overnight, while progress in conventional means of electric energy production will continue—one must think in terms of the efforts needed to bring about competitive atomic power in the future. Although as already pointed out, coal will still be the principal energy source of the electric power systems of the quarter century ahead, atomic power will nevertheless play a role in the production of the 2,000 billion kwhr visualized, but not until a lot of problems have first been solved. There are today electrical utility engineers actively engaged in research directed towards their solution and these efforts will have to be maintained and expanded. There is, for example, the Shippingport project where the heat to power a 60,000-kw steam turbine-generator will be developed from an atomic reactor. Much will be learned from this and other installations in the future through building and operating them. But the problems to be solved are numerous and difficult. There is the problem of radioactive waste dis-

posal; there are the problems of reactor technology and materials; and there are many problems created by the inherently hazardous nature of a nuclear reactor. All these are challenging and will require basic research in many fields. Since the utility engineer will be responsible for the final product, he cannot avoid his share of participation in working out the solutions.

The established trend of the efficiency of converting primary fuels into electricity has been upward for many years. Steam pressures have been increased from the 300–600 pounds per square inch (psi) level of a comparatively few years ago to the 2,000–2,300 psi of today's new equipment, with an accompanying increase in thermal efficiency so that in 1954 the most efficient steam-electric station had a heat rate of 9,100 Btu per kilowatt-hour. It has been evident, however, for some time that, if further gain was to be brought about economically, it would have to be brought about by a bold step forward. Such a step has been taken and there is well along in construction today on the American Gas and Electric Company system a super-critical pressure turbine-generator which will operate at 4,500 psi and whose thermal efficiency will be 40 per cent. In further prospect there are pressures as high as 15,000 psi which will be accompanied by higher temperatures and higher efficiencies. But this region is today an unknown one, as regards the properties of water and other materials. Not only will research and development have to be carried out to extend our knowledge of the behavior of water and steam, but also the properties of the materials that will go into the boilers and turbines will have to be studied; new alloys will have to be developed and tested. In this work, too, the utility engineer will have to play a leading part.

In the field of transmission of electric energy, a great deal of progress has been made in recent years towards the development of higher voltage systems. Increased power-system loads, increased size of generating units, concentration of generating capacity and, very importantly, a need to develop transmission capacity as economically as possible have all been factors in the decision to take the step to higher voltages. On the American Gas and Electric Company system, there is the substantial beginning of a 330,000-volt transmission system in operation today which will, when completed, serve as the backbone transmission for a power system with a peak of 15 million kw and an annual system input of over 90×10^9 kwhr. That this and perhaps still higher voltages will have to be extensively utilized in the 2,000-billion-kwhr-per-year systems of 25 years hence is almost axiomatic. One need only ponder on the relatively mere 471 billion kwhr produced by utility systems in the United States last year to realize its inevitability. A great deal of work has been done in developing the technology of this ultrahigh-voltage transmission, but a great deal more remains to be done. Particularly rewarding will be a more extensive knowledge of the fundamental nature of the corona and ionization phenomena which accompany the use of very high voltages.

Finally, the field of energy utilization presents many fascinating and challenging problems. An outstanding example is one encountered in the development of electric house heating and air conditioning. It seems certain that eventually all heating and air conditioning will be done by electricity alone or in combination with solar energy. The devising of an economical and efficient means of heat storage will be a great step forward in bringing about this development. The incentives for this are numerous. Perhaps the most exciting is the one that can easily be derived from a consideration of the conservation of primary fuels. If it is assumed that 67 per cent of the energy in fuel is converted to heat when burned directly for heating, then it is simple arithmetic to show that a heat pump with a coefficient of performance of $3^1/_2$, when supplied from an electric power system whose thermal efficiency of generation is 40 per cent and whose transmission and distribution efficiency is 80 per cent, will result in a saving in original fuel of over 40 per cent. Obviously the rewards of such an accomplishment are of great significance to the entire economy. But here, too, the utility engineer has an indispensable part to play.

Accomplishments of the past, and the developments of the future—of which those just mentioned are but a few—did not and will not just come about: They have been and will be the result of continuing thought, basic research, sound forward-looking engineering, and a great deal of effort. When consideration is given to the basic and ubiquitous role of electricity in our economy, one cannot fail to realize the importance and challenge of the problems ahead in electrical utility engineering.

Pump Performance Studied

Water-flow patterns in a pump test at the Westinghouse Electric Corporation Steam Division laboratory show effects of intake tunnels bringing circulating water into electric-power generating stations. The pump-test circuit determines effects of pump submergence, inlet-flow turbulence, and design variations of pump components. Pump operation is studied under dynamic conditions in this closed-circuit facility which tests models up to 12 inches in diameter with 3,000-gallons-per-minute capacity.

The Need for a National Science Policy

J. E. HOBSON
FELLOW AIEE

Technological development has produced for America the highest standard of living in history, but technology depends, in turn, on research. Thus, if our tremendous rate of production is to be continued, a national science policy must be formulated which will foster and maintain those conditions under which research can best be carried on.

PREDOMINANT in our modern American civilization, setting it apart from other civilizations and other times, are two unique and enduring capabilities. The first is the capability to free men from their spiritual and physical bonds. The second is the capability to confer material well-being through technological advancement. Technical development has brought to the western world, and especially to America, material wealth, ease, abundance, pleasure, and a standard of living hitherto undreamed of throughout all history.

Productivity, measured in goods produced per man-hour of effort as well as in dollars per man-hour, is the source of our high standard of living. In turn, scientific and technical knowledge, research and development activities, new industrial techniques, management skills, and labor efficiency are the ingredients of productivity.

Although productivity is the core of economic expansion, research is at the core of productivity, for it is research which creates new products, new processes, and techniques; which creates whole new industrial and consumer patterns. It is applied research which keeps our industrial machine, our free economy, thriving and virile. Research multiplies our natural resources. Research seeks, finds, analyzes, and applies facts which enable us to extend our limbs and our senses, to have dominion over much of the physical world.

At the present time, research is going forward at a rate that is probably somewhat in excess of $4 billion annually. In the 1920's annual expenditures were about $100 million, and in the 1930's about $200 million. In the early 1940's the rate jumped to about $900 million, and since then, with the enormous impact of war- and defense-inspired research programs, the rate has steadily increased to its present level. The rate for 1953 was $3.8 billion.

Heretofore, these effects have been difficult to discern in more than general terms. However, the National Science Foundation is conducting inquiries to put research expenditures into a proper perspective with other elements of the economy. The following figures should be credited to Dr. Raymond H. Ewell, assistant director of the National Science Foundation on leave from Stanford Research Institute. Implicit in this attempt to calculate the earned dividend on each dollar invested in research is the notion that if our economic, and therefore political, strength is dependent on productivity, so is productivity dependent upon research. It represents the first attempt to estimate quantitatively the economic return of research on a national basis.

One approach assumes that all research had been halted during the period 1928 through 1953 and, consequently, that the average national economic growth rate was 2.5 per cent per year instead of the actual 3 per cent. The cumulative loss in gross national product would have been $400 billion for the 25-year period. The actual cost of research and development in the United States during that same period, however, was about $30 billion, indicating a return on research investment of 13 to 1, 1,300 per cent.

Looked at another way, the National Science Foundation has computed that research and development conducted from 1928 to 1953, the same 25-year period, contributed a minimum of $43 billion to the gross national product in 1953—more than half of it in the categories of new products and lowered production costs alone. Over the same period research expenditures averaged $1.2 billion yearly. Comparing average investment with minimum return in one year, the ratio is 36 to 1.

NEED FOR A NATIONAL SCIENCE POLICY

THE NEED for a national science policy is clearly and simply to preserve, strengthen, and renew our democratic institutions through the free enterprise system that makes them possible. Some of its dimensions are suggested by plotting the curve of our national productivity. Its rise, of course, coincides with the curve of the whole economy: with employment, construction, consumer spending, and capital expenditure; with all the other accredited indexes of national health and prosperity. Increased productivity springs from technological advance, the progress of science and the applied industrial arts.

The picture, however, is not quite complete. From technology to productivity to prosperity and security, the steps fit together snugly. There appears to be no necessity, nor even an appropriate opportunity, for keying in some new national science policy. Government and

Essential substance of an address given before a section meeting of the American Institute of Chemical Engineers, San Francisco, Calif., April 18, 1955.

J. E. Hobson is director of Stanford Research Institute, Stanford, Calif.

industry, manufacturers, retailers, and consumers, all, by implication, already support financial and organizational policies designed to promote applied research and the advances in technology and material wealth that follow. It is this urge to progress, of course, which keeps our competitive economy rich and strong. The tremendous production machine we have built is proof enough of the success we have achieved.

Technology, it appears, pays off. And where does technology spring from? What is the original source of so-called progress? Technological advance, fantastic rates of production, technical wizardry—progress, if you will—all spring from new knowledge, new excursions into the unknown; from new facts about the physical world, the solar system, the universe we live in. New knowledge and new facts are revealed only by prodigious and painstaking efforts in basic, pure, fundamental research. This is the area in which a national policy, a national understanding and willingness to act, can and must become active.

All of our technology, all of our engineering, our high level of productivity are not enough. They cannot maintain themselves and breed upon themselves indefinitely. In their present state they cannot hope to supply food, clothing, shelter, and medicine for a world whose inhabitants will soon be counted in many billions. They cannot provide them with livelihood. They cannot even promise them survival.

Behind every technological advance lie years of patient experiment, observation, and deduction. Every new industry, new product, new system, or new technique is based on an early effort in fundamental scientific exploration.

THE RETURN ON RESEARCH

Achievements in fundamental science occur because of ideas, intuitions, doubts, and assumptions fermenting in gifted and restless minds which are capable of addressing themselves simply and freely to the innermost secrets of nature to the end that men may have new resources of knowledge to adapt for their convenience and pleasure, so that ultimately men may live together in comfort and peace. In our time, basic research investigations into atomic structure have given us nuclear power; into electromagnetism have given us radar and television; into aerodynamics have given us supersonic aircraft; into the properties of crystals have given us transistors. Basic research lay behind electric light, the internal combustion engine, steam power. And it is basic, fundamental research that explores the origin and nature of cosmic rays, the forces that contain and bind the nucleus, the riddle of photosynthesis and of the semiconductor, heat transfer, radioactive waste disposal, the blinding power of the sun.

It is clear that all technological history has been built upon advances in fundamental knowledge. A national science policy, which is to say a national frame of mind, an attitude of government and of the governed as well, must be so conceived and directed as to create and maintain an atmosphere in which fundamental scientists of the highest caliber are encouraged to think, explore, and experiment, to push back the boundaries of the unknown and the limitations of the known, to discover new facts, to provide new knowledge for engineering and industrial applications.

What is the return on fundamental research? The truth here, of course, is a paradox. One answer is that there is no payoff in immediate, tangible, or attributable profit. The other answer is that no giant brain yet conceived can conceive of a giant brain able to make even a guess at the magnitude of return. It is hard to put a price on gravity, or to tot up the dividends paid by the quantum theory. We cannot build a bridge of dollars across an electromagnetic field; no accounting system can evaluate the worth of relativity. But history is an open record. To whatever extent man has mastery over matter, to whatever extent he can control his environment or capture natural forces for his own use, his debt is to fundamental research.

Yet, the dollar sign is important to fundamental research and to national science policy. Salaries and expenses must be met, working space provided, laboratories equipped, and, above all, there must be time. What is fundamental research worth? We do have a kind of yardstick, pitifully small though it is. Total research expenditures by industry and government were $3.8 billion in 1953, almost exactly 1 per cent of gross national income. But only 7 per cent of government research dollars went to fundamental research, only 8 per cent of industry's dollars. At the most, then, 0.08 per cent of national income was expended in support of fundamental research.

Although there is urgency about the need for new policies which will redress this situation, care must be taken to keep out any hint of expediency. Crash programs will not work. It is not a matter of adjusting budgets and time schedules for a year or 2 years or 5 years. Wisdom and education, experience and experimentation, are not subject to the pressures of time. Neither industry nor government can anticipate or require specified results within a specified time. On the other hand, the well is bottomless. In the words of Dr. Willard F. Libby of the Atomic Energy Commission, "The principle of research is such that it leads to new research, to new investigations and to new queries, to new understanding and new thought. We cannot imagine that fruitful research will ever lead to a satiation or to an exhaustion or termination of the scientific fields."

THE ROLE OF GOVERNMENT

Policies become a practical matter in execution and implementation. If the need is acknowledged, how shall it be met? First, what shall be the role of government? Our government does have science policies, progressive and enlightened ones as far as they go, as far as government can comprehend the crisis. Tax laws have been revised to permit research expenditures to be treated as current expenses, or to be capitalized and written off within 5 years. Contributions for research and for scientific education are deductible tax items. The Federal Government supports vast research programs through the Department of Defense and other agencies and will appropriate even greater funds for applied research and development in coming years. Government solicits the assistance of highly qualified advisors in selecting research objectives, it seeks to contract for or

finance scientific work to be performed by nongovernment groups. It has created the National Science Foundation, which is becoming the executive branch's chief consultant on government's role in the scientific community. The Foundation supports more and more grants and scholarships for promising young scientists, and is pursuing its significant studies to analyze and evaluate national research expenditures.

But government is inefficient almost by definition. Administrative overhead costs are staggering, threads of policy are easily lost, the problems of protecting government-conducted research from political influence and group pressures, of assuring agreeable geographic distribution, are knotty beyond belief or reason. Above all, the concept of major or sole reliance on basic scientific research directed and supervised by government, no matter how enlightened or how benign, is unacceptable in a free enterprise system. Government's role must be largely fiscal and not operative, directive, or controlling.

Recognizing that applied research is rapidly consuming our stores of fundamental knowledge which can be replenished only through patient and prolonged research into the fundamentals of science, government should entertain concrete suggestions as to how research can be encouraged, stimulated, and financed. One suggestion is that a system of federal tax credits should be adopted; outright credit on final computed tax, not merely deductions. Broadly speaking, such a system would be comparable to the depletion allowance granted to oil producers, under which 27.5 per cent of all income is free and clear of taxes. Such a system might find 95 cents of industry's tax dollar going to government, while the other 5 cents would be set irretrievably beyond the grasp of the tax collector on condition that it be channeled into basic research effort through some other avenue.

In 1954 corporate tax liability of the industrial production segment of the economy was $11.3 billion. Under a 5-percent formula, $565 million of this total would have been diverted to the support of basic research. The magnitude of this sum, expressed another way, is 0.2 per cent of the value of industrial production—a modest enough figure and worth many times its face value.

INDUSTRY'S PART IN RESEARCH

INDUSTRY'S ROLE in developing a national science policy must also reflect new conceptions and a reorientation of thinking about the critical nature of fundamental research in society. The whole country, including government and fundamental research, runs on the wages, profits, expenses, investments, and taxes of industry. What provision does industry now make for advances in basic research and new knowledge?

Industry supports education and it must continue to do so on an expanded scale. Its contributions to colleges and universities are extensive already, but must be increased—not only to provide the plant necessary for handling new throngs of school-aged young people, but also to improve the quality of education, to attract and hold the most able teachers and professors.

Industry also supports basic research within its own walls, but whereas it has been found that applied research and engineering can be conducted efficiently in industrial laboratories, the prosecution of basic research, with a few outstanding and brilliant exceptions, has not been satisfactory. Program interruptions, difficulty in attracting appropriate scientific personnel and isolating them from the demands of current industrial operation, absence or denial of mechanisms for encouraging interchange of ideas and information with other scientists outside the company, are all considerations which mitigate against effective basic research in industrial laboratories. Scientists engaged in basic research must be free to meet and talk with whom they please, they must have the equipment necessary for conducting their experiments, and they must have solitude and time.

Industry also pays taxes, but by the time tax monies are churned through the bureaucratic mill the residue is hopelessly inadequate, too much having passed off into superfluous tributaries.

The situation, then, is simply this: Industry is ultimately the chief consumer of basic research; it is critically dependent upon an ever-replenished supply of fundamental scientific knowledge; present mechanisms are not geared to fill the need; a new concept, a new approach, new national science policies must be conceived.

STANFORD'S RESEARCH PROGRAM

TAX CREDITS and outright contributions are two sources of support. A third is through a program such as recently inaugurated at Stanford Research Institute in a preliminary experimental way. This is a public, nonprofit, applied-research corporation with no advertising budget, no sales budget, no dividends to pay, no income taxes; although it does pay all real estate, property, and other taxes. Allocation of surplus, which is earned like any profit-making organization, is limited by law and by charter to the support of basic research, the support of education, to area development, to the development of natural resources, and to areas of research not provided for by private programs. A part of the research fee and of the overhead rate recovered, is committed to the fulfillment of these chartered obligations. Foremost among them is the support of basic scientific research. Last year the institute conducted 53 such projects and appropriations will increase for similar work this year. The program is definitely not restricted just to work we at Stanford can perform ourselves. We hope to accumulate annually substantial funds which can be devoted to the support of a basic research laboratory at Stanford University, for example, and perhaps later at other institutions. What we are doing and will continue to do is to accumulate these funds by charging an override, or surcharge or assessment, on the cost of doing applied research; and by redirecting this extra cost to the financing of basic research. Since applied research is the user of basic research information and has drawn so heavily on the supply of both knowledge and scientific personnel, applied research should become an instrument for the encouragement, expansion, and emphasis of basic research programs. Applied research should pay its full share of the cost of basic research, which is the raw material it works with, and such payment should be re-

garded by industry as a normal part of the cost of applied research.

It is our earnest hope that other research and engineering laboratories, whether industrial, government, or independent, will undertake to implement similar programs. The system of an override on the cost of applied research can produce very substantial sums. If they can be augmented by even more substantial sums from a tax credit and by continued increase in donations and contributions then fundamental research will have a measure of support more nearly commensurate with its contributions to the vitality of our society and the strength of our economy.

AN ENVIRONMENT FOR RESEARCH

AT THIS POINT it becomes appropriate to look at the conditions under which fundamental research will be conducted. We have seen the many obstacles that confront it in government and industrial laboratories. The only other conventional source of fundamental research results is in the universities and colleges. University laboratories have housed some of the finest intellects the country has known and have produced much fundamental research of the greatest consequence and highest order. But the great task of universities, their first responsibility, is education. They should not be expected to satisfy the nation's ever-increasing basic research needs from their educational budgets. In view of pressing financial requirements, such a demand upon the potential resources of the universities would be patently unrealistic. Although many features of university life are apparently essential to the successful pursuit of new knowledge, not every element in the campus atmosphere in America today is conducive to research programs of the magnitude and concentration that must be provided for. At the same time, however, the university by its very nature and purpose is the natural center for basic research.

Perhaps we should turn to consideration of a kind of institution virtually new to this country. Particularly since the war we have seen how successfully independent applied research institutes can be operated. Is it not entirely feasible to suppose that independent basic research institutes can also be established with as much or more likelihood of success?

To a great extent such programs are available now at the Basic Research Institutes of the University of Chicago, at the Institute for Advanced Studies in Princeton, N.J., and at the Carnegie Institution of Washington, D.C. But there is another device to be considered perhaps even better suited to the disbursement of funds from such a variety of sources as have been outlined. This would be to create scientific centers or a complex of laboratories patterned after the great Kaiser Wilhelm Institutes or the Max Planck Society of Germany, where exhaustive fundamental studies in several fields are followed. Some of the specialized fields are more or less loosely co-ordinated with industrial problems, but emphasis throughout is centered on the advancement of fundamental knowledge. Scientific research training for young men is incorporated into the program of the Max Planck Institutes, but only at the most advanced levels under the highest form of "apprenticeship" system. Routine teaching is avoided.

Major financial resources are distributed to these institutions by the Stifterverband für die deutsche Wissenschaft (Donators' Association for the Advancement of Science), a private agency which collects funds from industry, the state governments, and from the federal government of Germany for the assistance of research. If we agree that government should not control funds earmarked for this purpose, if we also agree that our present method of allocating monies is essentially random, unco-ordinated policy, then we can seriously consider creating a new independent agency, a basic research fund similar to the Stifterverband. Such an agency, or series of agencies, supervised by men of ability, integrity, and vision, could bring cultivation of the sciences to a condition of unprecedented yield.

In 1932, a United States Senator maintained that science and invention were to blame for that period's unemployment in America. All of us, including the Senator, know now how bitterly sterile such bleak words of despair and denial are. Scientific knowledge culled from man's inspirations, doubts, and probings into the nature of life and the elements is our most priceless as well as our most desperately needed resource.

It requires God-given courage to be pessimistic in the teeth of the fateful challenges and destructive forces loose in the world today. Optimism springs from a positive conviction that our exhilarating notions of liberty and individual dignity, enterprise, and progress must rest on the sure base of a dynamic free economy which draws its basic nourishment from deep wells of scientific knowledge. A new national science policy, conceived in the urgency of the need for both survival and continued progress, should receive our most serious and creative consideration at this moment in our national history. It must satisfy the requirements of both necessity and sufficiency. Our present approach is woefully inadequate and we are most certainly losing ground. Without doubt, we are creative and inventive enough to form an adequate national science policy and all of us—industry, government, universities, and individuals—should be ready to support it.

New Mobile Substation

A 17-ton mobile unit substation will help utility companies meet steadily rising electric power requirements in the New Bedford, Mass., coastal area. Permanently mounted on a semitrailer, the unit contains all transformer and switchgear equipment needed to replace any of 17 permanent substations in the New Bedford Gas and Edison Light Company system.

In case of an emergency power failure, the unit can be used completely to replace a disabled substation. Connections could be made to the high-voltage and low-voltage circuits and service restored in a matter of minutes. It will be used temporarily to replace substations on which maintenance work is being done, allowing routine maintenance to be carried out at the most favorable times and without service interruptions.

Classified Bibliography on Insulated Conductors

A New System for Referencing Technical Data

L. F. HICKERNELL
FELLOW AIEE

In the light of current interest in the classification of technical data, this article describing the attempt of one technical committee to methodize reference material within its scope is published in the hope that it will encourage other technical committees to undertake similar projects covering subjects in their fields.

DR. VANNEVAR BUSH recently* pointed out the urgent need for a method which will enable us quickly and efficiently to find any item of information in our vast snowballing store of scientific literature. While coding and mechanization of the entire bulk is the goal envisioned by Dr. Bush, he suggests that various possible approaches be tried out with special sections of the record.

One such attempt has been made by the Committee on Insulated Conductors which in 1949 embarked on the task of compiling a bibliography. The technique evolved by the committee, although not highly mechanized, is innovational and may be adapted to other subjects.

The "Classified Bibliography on Insulated Conductors" (AIEE Special Publication *S-73*, June 1954) uses a loose-leaf format and is a radical departure from the usual chronological and/or subject lists. References are classified:

1. By years.....24 (1930–53)
2. By publications.....20
3. By main subjects.....12
4. By subsubjects.....64

CLASSIFICATION BY YEARS

THE LOOSE-LEAF FORMAT permits annual supplementary editions of eight or more pages shortly after the first of each year. The standing Standards and Publications Subcommittee currently is compiling the first additional issue (1954). Each member of the subcommittee is assigned one or more publications from which to select, list, and classify material on insulated conductors.

Annual classification permits reference to earliest, latest, or period literature, as required.

The bibliography begins with 1930, since a fairly comprehensive list of prior literature is contained in the "Underground Systems Reference Book," NELA Publication *050*, 1931, Appendix II.

CLASSIFICATION BY PUBLICATIONS

REFERENCES first are grouped according to 14 classifications of publications which regularly publish material on insulated conductors; namely:

1. Association proceedings.....6
2. Trade periodicals.....8

and into six general or selected categories:

3. Association publications.
4. University publications.
5. Government publications.
6. Manufacturers, publications.
7. Books.
8. Selected articles.

Publication classification enables the user to confine his search of the literature to such publications as are readily available to him. Through familiarity with the nature of the publications, he can select the type of data required; for example, AIEE *Transactions* for theory, *Electrical World* for application.

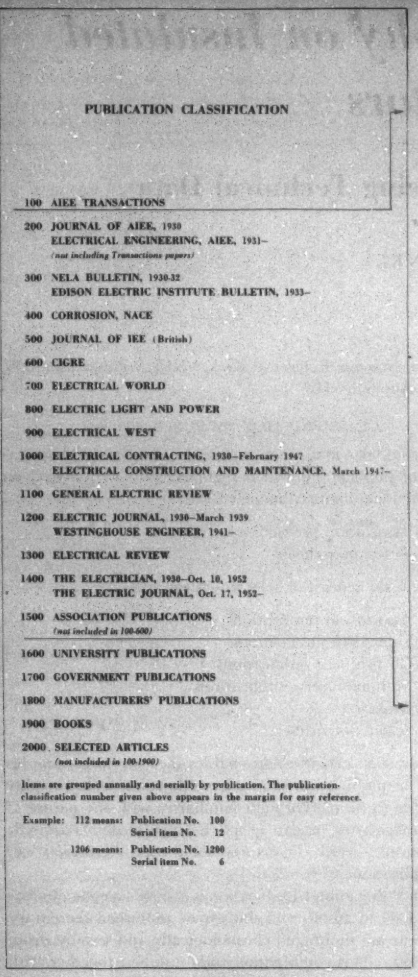
Each Publication Classification is assigned a code number (from **1** 00 to **20** 00) and the papers published therein for each year are numbered chronologically and serially (from 01 to 99). This combination code number, together with the last two digits of the year as a prefix, forms a complete reference to any paper listed in the bibliography. For example, **51-106** completely identifies a paper entitled "Lead-Alloy Sheaths for Underground Power Cable," by Herman Halperin and C. E. Betzer, AIEE *Transactions*, vol. 70, pt. 1, 1951, pp. 423–35 (see illustration).

CLASSIFICATION BY MAIN SUBJECTS

IN 1947 when the committee was organized, considerable thought was given to a standing subcommittee organization which would cover the entire scope. This resulted in the formation of 12 subcommittees. Two years of experience in administration of the committee having demon-

L. F. Hickernell is chairman, AIEE Committee on Planning and Co-ordination, and was the initial chairman (1947–49), AIEE Committee on Insulated Conductors.

* "Communication—Where Do We Go From Here?" *Electrical Engineering*, vol. 74, no. 5, May 1955, pp. 367–70.



PUBLICATION CLASSIFICATION

100 AIEE TRANSACTIONS

200 JOURNAL OF AIEE, 1930
ELECTRICAL ENGINEERING, AIEE, 1931–
(not including Transactions papers)

300 NELA BULLETIN, 1930-32
EDISON ELECTRIC INSTITUTE BULLETIN, 1933–

400 CORROSION, NACE

500 JOURNAL OF IEE (British)

600 CIGRE

700 ELECTRICAL WORLD

800 ELECTRIC LIGHT AND POWER

900 ELECTRICAL WEST

1000 ELECTRICAL CONTRACTING, 1930–February 1947
ELECTRICAL CONSTRUCTION AND MAINTENANCE, March 1947–

1100 GENERAL ELECTRIC REVIEW

1200 ELECTRIC JOURNAL, 1930–March 1939
WESTINGHOUSE ENGINEER, 1941–

1300 ELECTRICAL REVIEW

1400 THE ELECTRICIAN, 1930–Oct. 10, 1952
THE ELECTRIC JOURNAL, Oct. 17, 1952–

1500 ASSOCIATION PUBLICATIONS
(not included in 100-600)

1600 UNIVERSITY PUBLICATIONS

1700 GOVERNMENT PUBLICATIONS

1800 MANUFACTURERS' PUBLICATIONS

1900 BOOKS

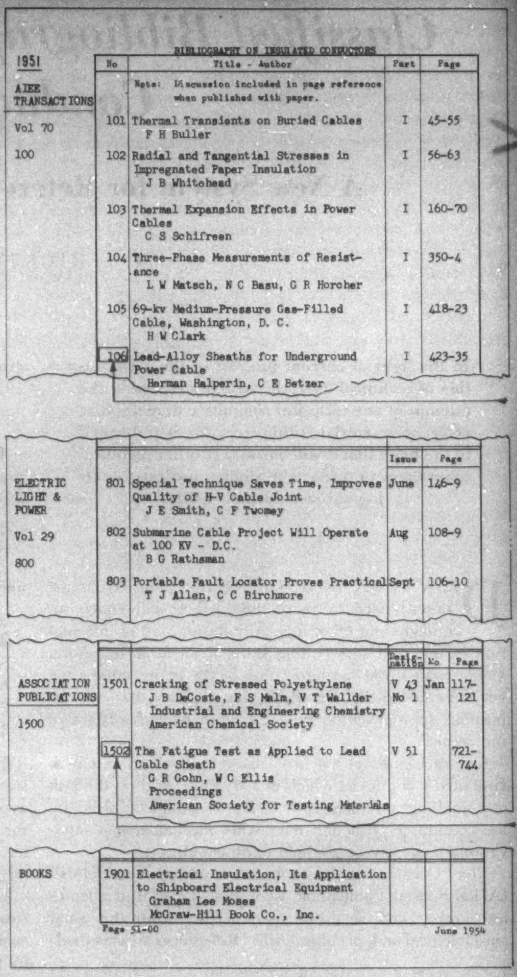
2000 SELECTED ARTICLES
(not included in 100-1900)

Items are grouped annually and serially by publication. The publication-classification number given above appears in the margin for easy reference.

Example: 112 means: Publication No. 100
Serial item No. 12

1206 means: Publication No. 1200
Serial item No. 6

Front-cover flap



BIBLIOGRAPHY ON INSULATED CONDUCTORS

1951

	No	Title - Author	Part	Page
AIEE TRANSACTIONS		Note: Discussion included in page reference when published with paper.		
Vol 70	101	Thermal Transients on Buried Cables F H Buller	I	45-55
100	102	Radial and Tangential Stresses in Impregnated Paper Insulation J B Whitehead	I	56-63
	103	Thermal Expansion Effects in Power Cables C S Schifreen	I	160-70
	104	Three-Phase Measurements of Resistance L W Matsch, N C Basu, G R Horcher	I	350-4
	105	69-kv Medium-Pressure Gas-Filled Cable, Washington, D. C. H W Clark	I	418-23
	106 A	Lead-Alloy Sheaths for Underground Power Cable Herman Halperin, C E Betzer	I	423-35

			Issue	Page
ELECTRIC LIGHT & POWER	801	Special Technique Saves Time, Improves Quality of H-V Cable Joint J E Smith, C F Twomey	June	146-9
Vol 29	802	Submarine Cable Project Will Operate at 100 KV - D.C. B G Rathsman	Aug	108-9
800	803	Portable Fault Locator Proves Practical T J Allen, C C Birchmore	Sept	106-10

			Publication	No	Page
ASSOCIATION PUBLICATIONS	1501	Cracking of Stressed Polyethylene J B DeCoste, F S Malm, V T Wallder Industrial and Engineering Chemistry American Chemical Society	V 43 No 1	Jan	117-121
1500	1502 A	The Fatigue Test as Applied to Lead Cable Sheath G R Gohn, W C Ellis Proceedings American Society for Testing Materials	V 51		721-744

BOOKS	1901	Electrical Insulation, Its Application to Shipboard Electrical Equipment Graham Lee Moses McGraw-Hill Book Co., Inc.	

Page 51-00 June 1954

Left-hand page

strated the adequacy of the subcommittee divisions, it was quite logical to adopt the subcommittee names, with minor modifications, as the main subjects for the bibliography. These are shown in bold-faced type in the illustration (back-cover flap).

A concomitant benefit in the use of subcommittee numbers as main subjects is the automatic provision of an annual record of activity within each subcommittee's scope.

CLASSIFICATION BY SUBSUBJECTS

SINCE 12 main subjects are inadequate for maximum utility, these are subdivided further into 64 subsubjects, varying in number from 0 to 8 (see illustration, Subject Classification, back-cover flap).

FORMAT

THE FORMAT of the Subject Classification resembles a log table (see illustration, right-hand page). With this arrangement it is possible to subclassify under as many subjects as the paper covers (see Paper 105).

EXAMPLE

TO FIND references on lead sheath published in **1951**, proceed as follows (see illustration):

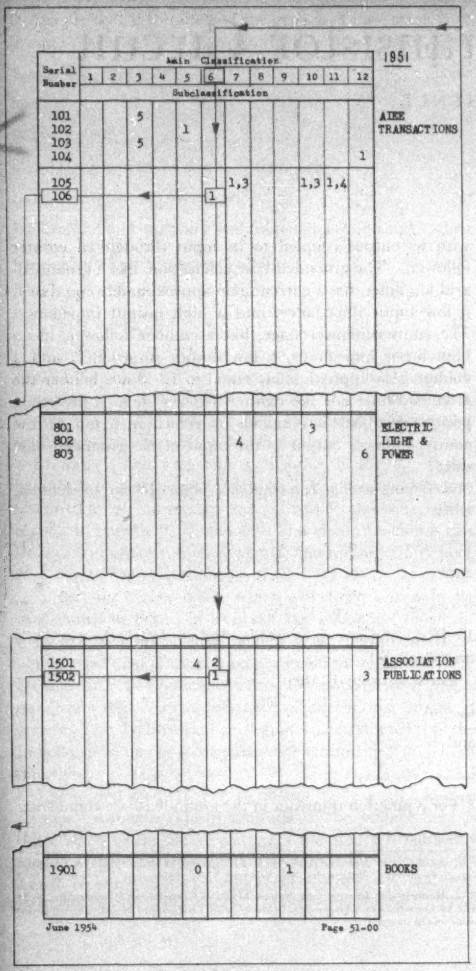
1. Open front- and back-cover flaps

On back-cover flap,

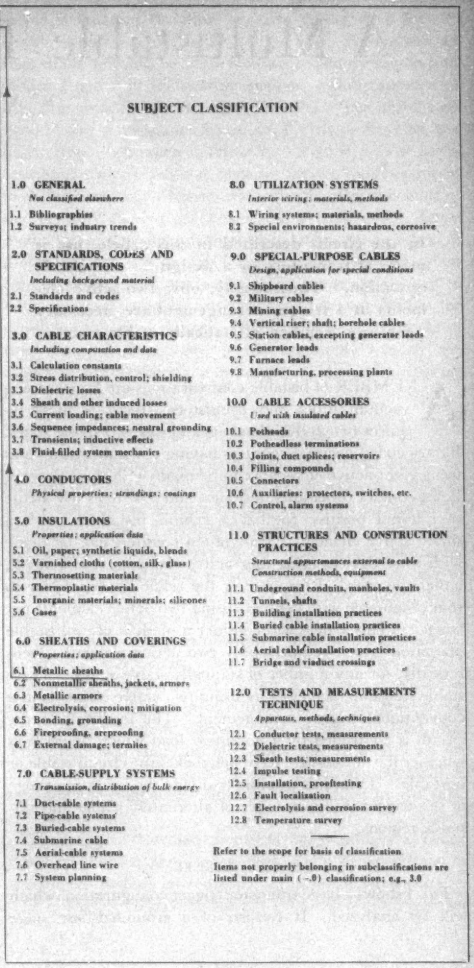
2. Find **6.1 Metallic Sheaths** under Subject Classification

On right-hand page,

3. Under **Column 6,** find **Numeral 1** (i.e., 6.1)



Right-hand page



SUBJECT CLASSIFICATION

1.0 GENERAL
Not classified elsewhere
1.1 Bibliographies
1.2 Surveys; industry trends

2.0 STANDARDS, CODES AND SPECIFICATIONS
Including background material
2.1 Standards and codes
2.2 Specifications

3.0 CABLE CHARACTERISTICS
Including computation and data
3.1 Calculation constants
3.2 Stress distribution, control; shielding
3.3 Dielectric losses
3.4 Sheath and other induced losses
3.5 Current loading; cable movement
3.6 Sequence impedances; neutral grounding
3.7 Transients; inductive effects
3.8 Fluid-filled system mechanics

4.0 CONDUCTORS
Physical properties; strandings; coatings

5.0 INSULATIONS
Properties; application data
5.1 Oil, paper; synthetic liquids, blends
5.2 Varnished cloths (cotton, silk, glass)
5.3 Thermosetting materials
5.4 Thermoplastic materials
5.5 Inorganic materials; minerals; silicones
5.6 Gases

6.0 SHEATHS AND COVERINGS
Properties; application data
6.1 Metallic sheaths
6.2 Nonmetallic sheaths, jackets, armors
6.3 Metallic armors
6.4 Electrolysis, corrosion; mitigation
6.5 Bonding, grounding
6.6 Fireproofing, arcproofing
6.7 External damage; termites

7.0 CABLE-SUPPLY SYSTEMS
Transmission, distribution of bulk energy
7.1 Duct-cable systems
7.2 Pipe-cable systems
7.3 Buried-cable systems
7.4 Submarine cable
7.5 Aerial-cable systems
7.6 Overhead line wire
7.7 System planning

8.0 UTILIZATION SYSTEMS
Interior wiring; materials, methods
8.1 Wiring systems; materials, methods
8.2 Special environments; hazardous, corrosive

9.0 SPECIAL-PURPOSE CABLES
Design, application for special conditions
9.1 Shipboard cables
9.2 Military cables
9.3 Mining cables
9.4 Vertical riser; shaft; borehole cables
9.5 Station cables, excepting generator leads
9.6 Generator leads
9.7 Furnace leads
9.8 Manufacturing, processing plants

10.0 CABLE ACCESSORIES
Used with insulated cables
10.1 Potheads
10.2 Potheadless terminations
10.3 Joints, duct splices; reservoirs
10.4 Filling compounds
10.5 Connectors
10.6 Auxiliaries: protectors, switches, etc.
10.7 Control, alarm systems

11.0 STRUCTURES AND CONSTRUCTION PRACTICES
Structural appurtenances external to cable
Construction methods, equipment
11.1 Underground conduits, manholes, vaults
11.2 Tunnels, shafts
11.3 Building installation practices
11.4 Buried cable installation practices
11.5 Submarine cable installation practices
11.6 Aerial cable installation practices
11.7 Bridge and viaduct crossings

12.0 TESTS AND MEASUREMENTS TECHNIQUE
Apparatus, methods, techniques
12.1 Conductor tests, measurements
12.2 Dielectric tests, measurements
12.3 Sheath tests, measurements
12.4 Impulse testing
12.5 Installation, proofTesting
12.6 Fault localization
12.7 Electrolysis and corrosion survey
12.8 Temperature survey

Refer to the scope for basis of classification
Items not properly belonging in subclassifications are listed under main (–.0) classification; e.g., 3.0

Back-cover flap

4. Under left-hand column, find **Serial nos. 106** and **1502**

On left-hand page,

5. Identify **Paper no. 106** by title, author, publication, volume number, year, and page numbers as: "Lead-Alloy Sheaths for Underground Power Cable by Herman Halperin," C. E. Betzer, AIEE *Transactions*, vol. 70, pt. I, 1951, pp. 423–25
and **Paper no. 1502** as:
"The Fatigue Test as Applied to Lead Cable Sheath," by G. R. John, W. C. Ellis
ASTM *Proceedings*, vol. 51, 1951, pp. 721–44

Additional years and publications may be searched in a similar manner.

MACHINE TABULATION

SINCE the conventional business tabulating machine provides 80 columns, it is possible to punch cards and conduct a search automatically by the method developed for this bibliography.

REFERENCES

IN WRITING PAPERS, it is customary to refer to previous work by numbered references tabulated at the end of the paper. Confusion during several drafts caused by rearrangement of manuscript may be avoided by using these Bibliography code numbers (year-serial number) in parentheses (e.g., 51-106) in the manuscript in place of superscripts in numerical sequence [1,2,3].

A Multistable Transistor Circuit

R. A. HENLE

In the circuit described in this article, use is made of transistors in a design for multistable operation. Theoretically, only two active elements in a trigger arrangement are necessary for any number of statically stable states.

A NUMBER of bistable configurations are known using vacuum tubes and transistors. Each of these requires two active elements and has two stable states. Binary coded decimal counters having ten stable states and using eight active elements can be made with these devices. Point-contact transistors, tetrodes, and gas tubes (by virtue of internal positive feedback) exhibit bistability with a single active element. Scale-of-ten counters can be made with these devices using four active elements. In general, either the speed of response or the reliability is inferior to that obtainable with counters using two active elements per trigger. This article will consider a method of multistable operation which requires only two active elements, theoretically, for any number of statically stable states. These stable states are achieved by using two active elements in a conventional trigger arrangement. The feedback in the circuit is controlled by a nonlinear load which determines whether the net positive feedback makes the circuit stable or unstable. Thus, it is possible to divide the operating range of the trigger into a number of alternately stable and unstable regions.

BASIC CIRCUIT

FIG. 1 shows a basic transistor trigger configuration, which will be analyzed. It consists of a grounded-base stage with its output coupled to its input through an emitter follower. The grounded-base connection, like a grounded-grid amplifier, has a current gain approximately equal to 1, a low input impedance, and a high output impedance. The emitter-follower stage, like a cathode follower, has a high input impedance, a low output impedance, and a voltage gain approximately equal to 1. Since neither the grounded-base nor the emitter-follower stage is inverting, positive feedback is obtained by returning a tap on the emitter-follower output to the input of the grounded-base stage.

Referring to Fig. 1, a feedback factor AB can be defined, where

$$A = i_{out}/i_{in} \tag{1}$$

and

$$B = i_{feedback}/i_{out} \tag{2}$$

If $AB<1$ the circuit is stable, and if $AB>1$ the circuit is unstable.

For small signals, then

$$i_{out} = dI_c \tag{3}$$

and

$$_{feedback} = dI_{feedback} \tag{4}$$

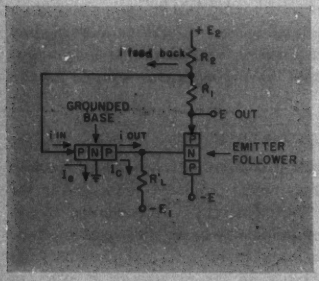
For a junction transistor in the grounded-base connection

$$\alpha = i_{out}/i_{in} = A \tag{5}$$

Full text of a paper presented before the AIEE–Institute of Radio Engineers Transistor Circuit Conference, Philadelphia, Pa., February 17–18, 1955.

R. A. Henle is with International Business Machines Corporation, Poughkeepsie, N. Y. The author wishes to acknowledge the many helpful suggestions of J. Logue while this work was in progress.

Fig. 1. Transistor trigger circuit. Fig. 2. Collector V-I characteristic with step load line. Fig. 3. Diode clamped load



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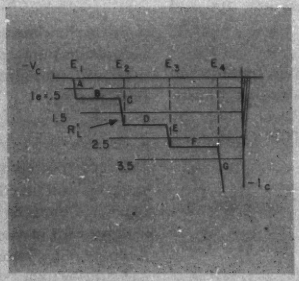

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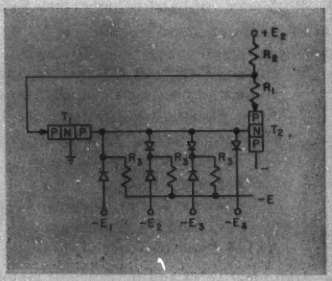

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Assume that the emitter of the grounded-base stage is at ground potential when biased in the forward direction, then

$$I_{feedback} = E_{out}/R_1 + E_2/R_2 \tag{6}$$

and

$$E_{out} = I_c R_L' - E_1 \tag{7}$$

Combining equations 6 and 7, then

$$I_{feedback} = I_c R_L'/R_1 - E_1/R_1 + E_2/R_2 \tag{8}$$

Differentiating equation 8 and using equations 3 and 4, then

$$dI_{feedback}/dI_c = R_L'/R_1 = i_{feedback}/i_{out} = B \tag{9}$$

Then

$$AB = \alpha R_L'/R_1 \approx R_L'/R_1 \tag{10}$$

Therefore, for $R_L' > R_1$ the circuit will be unstable and for $R_L < R_1$ the circuit will be stable. If then, a load line with alternate regions of $R_L' > R_1$ and $R_L' < R_1$ could be constructed, a circuit with alternate regions of unstable and stable operating points would be obtained.

Consider a load line, such as is shown in Fig. 2. If this load line is represented by $R_L' = F(I_c)$, small values are obtained for R_L' in regions *A*, *C*, *E*, and *G*, and large values for R_L' in regions *B*, *D*, and *F*. Therefore, the circuit can be stable in regions *A*, *C*, *E*, and *G*, and unstable in regions *B*, *D*, and *F* by proper choice of R_1.

A load line can be made, which will closely approximate that shown in Fig. 2 in several ways; these are shown in Figs. 3 and 4. The first method (Fig. 3) utilizes diodes with the position of the steps determined by voltages E_1, E_2, E_3, and E_4. The resistance of the low-impedance region is essentially the forward resistance of one or two diodes in series. The high-resistance region is determined by the impedance of one or more current generators $-E$ and R_3 in parallel.

The second method (Fig. 4) utilizes diodes with a known "Zener" voltage. The magnitude of the voltage step is determined by the Zener voltage of the diodes. The magnitude of the current step is determined by $-E$ and R_3. Let R_f be equal to the forward resistance of the Zener diode and Rz be equal to the resistance of the Zener region. Then the impedance of the most negative voltage step for the circuit of Fig. 4 would be $Rz_1 + Rz_2 + Rz_3$. For the second step, diode *1* would be in its forward resistance region and diodes *2* and *3* in their Zener regions. The resistance of this step would then be $R_{f1} + Rz_2 + Rz_3$. The third step would have a resistance equal to $R_{f1} + R_{f2} + Rz_3$ and the fourth step a resistance equal to $R_{f1} + R_{f2} + R_{f3}$. The high-resistance regions between steps, as for the diode-clamped load line, would be determined by the parallel resistance of one or more current generators $-E$ and R_3. The Zener diodes offer definite advantages in that the number of diodes required is one half the number required when conventional diodes are used. Also it is not necessary to have separate supplies or a low-impedance divider for supplying the step voltages. They have a disadvantage in that each low-impedance region essentially has all the diodes in series making it necessary to design the circuit with a larger value for R_1.

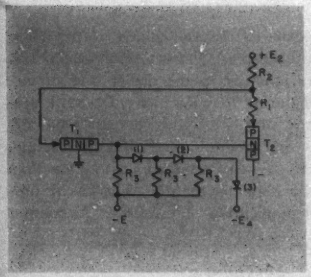
TRIGGERING SCHEMES

PRECAUTIONS must be taken in the manner in which the circuits are triggered. Unlike a conventional trigger, which may be set or reset by pulses above a certain minimum amplitude, a circuit of this type obviously requires an upper limit on the energy of the input triggering pulse. Too strong a triggering pulse could cause the circuit to jump several steps. A number of triggering schemes have been tried and are shown in Figs. 5 and 6.

Fig. 5 utilizes a capacitor input. The time constants R_4, C_4, R_3, C_3, and circuit values are chosen so that when a voltage step is applied to the input, a step of current flows through R_L'. This step of current can be designed to be equal to one or more current steps on the step load line. The circuit will count up for positive inputs and down for negative inputs. A disadvantage of this arrangement is that the rise time at the output is also limited by the time constant R_3C_3.

The triggering arrangement of Fig. 6 utilizes a Zener diode to quantize the trigger steps. The Zener voltage of the silicon diode is chosen to be equal to the step voltage. The quiescent voltage of point *A* is one step more positive

Fig. 4. "Zener" diode load. Fig. 5. Triggering method A. Fig. 6. Triggering method B



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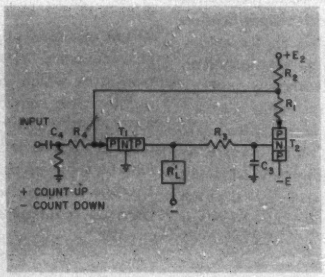

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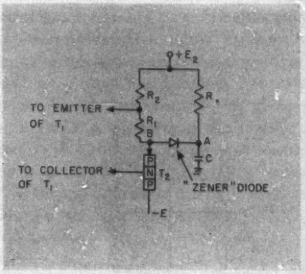


6

than the quiescent voltage of point B. When a positive pulse is applied to the emitter or collector of T_1, the voltage at point B starts to rise, but is clamped by the Zener diode at the voltage of point A for a period of time sufficiently long so to allow the circuit to stabilize at the new voltage. Capacitor C will then charge to a voltage one step more positive than point B, and the circuit is ready for the next input pulse.

A similar scheme, likewise, could be arranged to make a count-down input.

Another method of triggering would be to have the trigger input at the base of a p-n-p inverter stage which had its collector attached to the collector of T_1. Application of a negative pulse at the input would pull the collector of T_1 to the emitter potential of the inverter; this potential would be adjusted to be one step more positive than the collector potential of T_1.

Also, an n-p-n transistor could be used in a similar circuit for a count-down input.

SPEED OF OPERATION

THERE APPEARS to be no reason why circuits of this type cannot be as fast or faster than more conventional circuits using similar transistors. The multistable circuit has an advantage in that if properly designed, neither transistor is permitted to go into saturation; thus, minority carrier storage problems are eliminated. In a conventional transistor trigger with two stable states (not employing special circuitry), one transistor will normally be in saturation and one transistor normally cut off. The transistor in saturation will always require a certain finite time to clear out the minority carriers when changing state. This limits the response time of the circuit for a particular drive pulse.

The circuit has another advantage in that it is not particularly dependent upon the characteristics of the transistors used. The grounded-base stage can use nearly any junction transistor since it is only necessary that α be close to 1. Transistors with $\alpha>0.95$ are more than adequate. Large values of I_{co} and the temperature dependence of I_{co} present no problem with the grounded-base stage. The emitter-follower stage is also noncritical with respect to the α of the transistors used, and again $\alpha>0.95$ is sufficient. A typical emitter-follower stage will have a stability factor S^1 (where $S=\alpha I_c/\alpha I_{co}$) of about 1.3, so again I_{co} is not a critical parameter. Therefore, it can be seen that transistors with wide variations in α and noncritical specifications

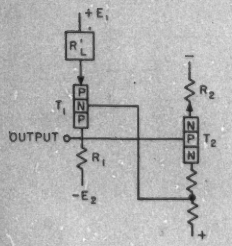


Fig. 7. A p-n-p–n-p-n multistable circuit

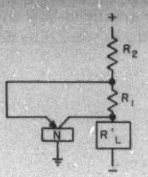


Fig. 8. Single-transistor multistable circuit

on I_{co} are more than adequate. A circuit having ten stable states has been constructed and no difficulty was experienced in interchanging transistors. Since a large change in transistor characteristics would be necessary for circuit failure, it would be expected that the circuit life would be long compared with grounded-emitter operation of transistors.

OTHER MULTISTABLE CONFIGURATIONS

THE PRINCIPLE of multistable operation is not limited to the configuration shown, but can be incorporated in other trigger arrangements. In Fig. 7 is shown a circuit which has its stable operating regions along the constant-current portions of the multistable load line. Assume T_1 is operating along a constant-current region. Then variations in the base voltage of T_1 will cause little or no variation in the output voltage and, therefore, no change in the voltage fed back to the base of T_1. Hence, the circuit is at a stable operating point. However, if T_1 were operating along a constant-voltage region of the multistable load line, then small changes in the base voltage of T_1 would cause larger changes in the output voltage. These changes are fed into the base of T_2 causing changes in the collector voltage of T_2 which are fed back to the base of T_1. The circuit is unstable in this region.

Fig. 8 illustrates a single transistor trigger ($\alpha>1$) with a step load giving multistable operation. The operation of this circuit would be similar to that of the first circuit described. In general, conventional point-contact transistors would not be satisfactory since predictable uniform and pentode-like characteristics are most desirable for the circuit.

CONCLUSION

THE CIRCUIT appears to be well suited to transistor characteristics. It utilizes those characteristics of junction transistors which are inherent in the device and do not require close control during manufacture. Desirable features of the circuit are that it can theoretically have any number of statically stable states, and that these states may be achieved using only two transistors with α less than 1 or one transistor with α greater than 1. This circuit provides an economical application of transistors to counter circuits.

REFERENCE

1. Principles of Transistor Circuits (book), **R. F. Shea.** John Wiley and Sons, Inc., New York, N. Y., 1953, pp. 44–8.

Impulse Tests on Low-Voltage Windings of Distribution Transformers

J. E. HOLCOMB
MEMBER AIEE

These tests are discussed from the viewpoint of field investigations and transient considerations, the transient behavior of distribution transformers, fault detection by induced-voltage-wave method, comparison of fault-detection methods when testing high-voltage windings, and impulse testing low-voltage windings of large high-voltage distribution transformers.

FOR IMPULSE TESTING of transformers, the American Standards (*C57*, paragraph *22.115*) specify a $1^1/_2$x40-microsecond (μsec) wave. Many distribution transformers have low-voltage windings rated 600 volts or less. These windings have very few turns and therefore have very low impedance to impulse voltage waves. For this reason an excessively large impulse generator would be required to apply a $1^1/_2$x40-μsec wave from terminal to terminal of the winding. Even if an impulse generator of sufficient capacity were available, the application of a $1^1/_2$x40-μsec wave to the low-voltage winding would in many cases induce excessively high voltages in the high-voltage winding.

For these reasons these standards permit the test to be made by connecting the low-voltage terminals together and applying the impulse from terminals to ground. This tests the insulation to ground but not the internal insulation of winding. For a quality-control test to do a thorough job, it must include a test which will stress the turn and layer insulation in the low-voltage coil. Such a test has been included on a production basis in the quality-control test since 1952.

A comparison of the ratios of the impulse crest voltages to the 60-cycle rms operating voltages for oil-filled distribution transformers is shown in Table I. This table shows that the highest ratios (Basic Impulse Level: rms voltage) occur in the lowest voltage ratings.

Table I

Typical 60-Cycle Operating Voltage (rms)	Typical Impulse BIL, Kv Crest	Ratio—BIL to Operating Voltage
240	30	125
480	30	62.5
2,400	60	25
4,800	75	15.6
7,200	95	13.2
13,200	95	7.2

It follows that if a low-voltage winding is subjected to an impulse voltage with a crest value equal to the corresponding basic impulse insulation level (BIL), and if an electromagnetically induced voltage equal to this value multiplied by the turn ratio should appear across the high-voltage winding, the latter winding would be subjected to a voltage far in excess of its BIL.

The problem of protecting the high-voltage windings during impulse tests on low-voltage windings is a serious one. The terminal voltages can be controlled by the use of external impedances or even by short-circuiting the winding; but voltages between parts of the winding cannot always be controlled in this manner. In fact, in some cases the internal voltage gradients may actually be increased when the winding is loaded by an impedance. Unfortunately it is not always possible to predict what these voltage gradients will be for a particular transformer without an expensive and time-consuming investigation. There is the added disadvantage that on many transformers a short-circuited winding will drastically reduce fault-detection sensitivity, and the test should not be simplified at the expense of this sensitivity.

The same comparison of the ratios of the impulse crest voltages to the 60-cycle rms operating voltages show that an impulse test on the high-voltage winding will induce only very small voltages in the low-voltage winding and will not adequately test the latter winding. For these reasons a completely reliable quality-control impulse test must include a test designed primarily to test the transformer low-voltage windings.

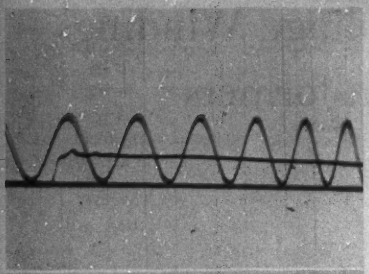
FIELD INVESTIGATION RESULTS AND TRANSIENT CONSIDERATIONS

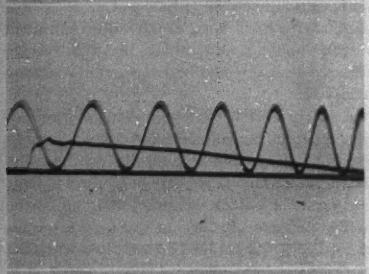
OTHER INVESTIGATORS[1,2] have shown that a large percentage of the lightning surges which arrive at transformers in service do so by way of the low-voltage lines. This emphasizes the desirability of a searching test on the low-voltage winding because in service it is almost as likely to be subjected to lightning surges as the high-voltage winding.

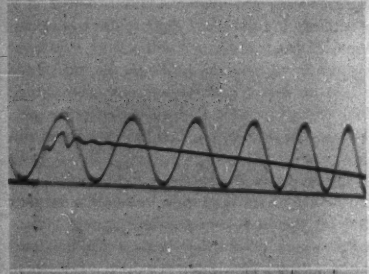
These investigators[1] have shown that when lightning strikes in the vicinity of a transformer in service, the ground potential is raised and the lightning currents flow outward on every possible path. If the midtap of the transformer low-voltage winding is connected to ground, the surge currents will then flow outward through the two halves of the low-voltage winding so that the effect of these two cur-

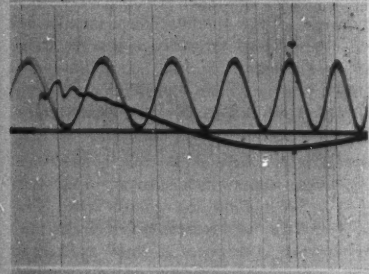
Full text of conference paper CP55-27 presented at a session of the AIEE Committee on Transformers, AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955.

J. E. Holcomb is with the General Electric Company, Pittsfield, Mass.









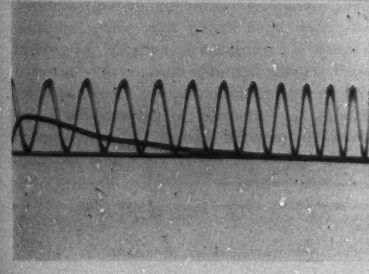


Fig. 1. Voltage induced on 7,200-volt winding of 10-kva 7,200–120/240-volt transformer with no fault when a 0.5x1.5-microsecond (μsec) wave is applied to the 120-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 2. Voltage induced on the 7,200-volt winding of 10-kva 7,200–120/240-volt transformer with a 1-turn fault when a 0.5x1.5-μsec wave is applied to the 120-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 3. Voltage induced on the 2,400-volt winding of 10-kva 2,400–120/240-volt transformer with no fault when a 0.5x1.5-μsec wave is applied to the 120-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 4. Voltage induced on 2,400-volt winding of 10-kva 2,400–120/240-volt transformer with a 1-turn fault when a 0.5x1.5-μsec wave is applied to the 120-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 5. Voltage across an impedance in the neutral of a 10-kva 7,200–120/240-volt transformer with no fault when a 1½x40-μsec wave is applied to the 7,200-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period

rents might be expected to cancel out, leaving no net electromagnetic effect. In an actual transformer the two halves of the low-voltage winding cannot occupy identical locations, so there is never a perfect current balance or flux cancellation. In fact, the voltage induced in the high-voltage winding by this surge current has been found to be similar to that induced by a short-tailed impulse wave applied between terminals of the low-voltage winding.

Almost all consumer equipment (rated 600 volts or less) has an insulation level which will not withstand impulse voltages of 25 kv for periods exceeding 1 or 2 μsec. Such equipment can be expected to flashover when impulse waves of longer duration are applied even if the voltage is considerably lower than 25 kv. Because of this and because the secondary conductors between the distribution transformer and the consumers' premises are usually short, seldom exceeding 1,000 feet in length, it is unlikely that in service surges of 25-kv magnitude exceeding 1 or 2 μsec in length will be applied to distribution transformer low-voltage windings.

The practice of applying short-tailed impulse waves between terminals of the low-voltage windings of distribution transformers on a production basis was started in 1952.[3] Since that time many thousands of transformers have been tested and put into service. The very small number of customer complaints on transformers which have been tested in this manner indicate that a test of this type is very effective in weeding out faulty transformers, and that transformers that will withstand such a test will successfully withstand surges which might be expected in service.

TRANSIENT BEHAVIOR OF DISTRIBUTION TRANSFORMERS

IT HAS BEEN STATED in a previous paper[4] that when a rectangular traveling wave is applied to the high-voltage winding of a power transformer the voltages within the transformer windings consist of four components:

1. A voltage transmitted electrostatically to the low-voltage winding, depending on the relations of distributed capacitances of the low-voltage winding to the high-voltage

winding and ground, and is independent of the turn ratios.

2. A free oscillation in the high-voltage winding, consisting of a number of space harmonics, through the electromagnetic and electrostatic fields induces a corresponding forced oscillation in the low-voltage winding.

3. A free oscillation in the low-voltage winding, depending on the distributed constants of the winding.

4. A unidirectional voltage surge transmitted to the low-voltage winding by electromagnetic induction which is very nearly directly proportional to the turn ratio and is independent of the distributed capacitance. It is a simple function of the short-circuit inductance of the transformer and of the surge impedances of external circuits.

The same principles apply when the impulse voltage is applied to the low-voltage windings of distribution transformers. However, the voltage transmitted by the capacitance relationship from the low-voltage winding to the high-voltage winding is negligible. Also, because of the few turns in the low-voltage windings, the oscillations in this winding are negligible. The free oscillations in the high-voltage windings are of considerable importance since they affect the internal stresses in this winding. It is well known that the front of the induced wave is sloped off by the leakage reactance between transformer windings. Because of the relatively slow rate of rise of this induced wave, its peak value may be controlled by shortening the length of the tail of the applied wave. Thus, by applying the proper waveshape to the low-voltage winding, the magnitude of the voltage wave induced in the high-voltage winding can be controlled even though the peak voltage of the applied wave is held at the level required by the American Standards. This provides an effective means of testing transformers because the insulation in all the windings can be properly stressed. However, because the applied voltage wave is short the usual fault detection methods may not be applicable.

FAULT DETECTION BY INDUCED-VOLTAGE-WAVE METHOD

CONSIDERABLE EXPERIMENTATION was undertaken around 1940 to develop impulse test equipment which would apply

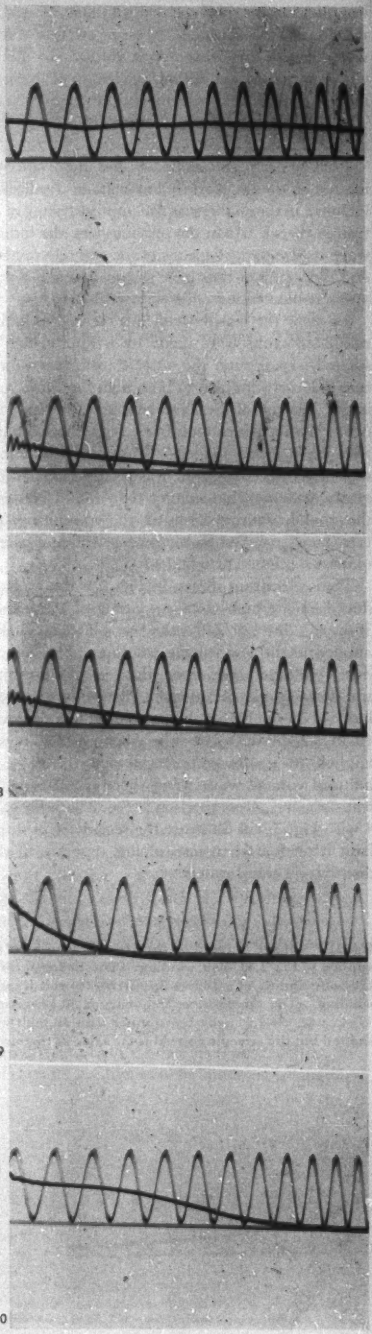


Fig. 6. The voltage across an impedance in the neutral of a 10-kva 7,200–120/240-volt transformer with a 1-turn fault when a $1^1/_2$x40-μsec wave is applied to the 7,200-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 7. Voltage induced on the 120-volt winding of a 10-kva 7,200–120/240-volt transformer with no fault when a $1^1/_2$x40-μsec wave is applied to the 7,200-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 8. Voltage induced on the 120-volt winding of a 10-kva 7,200–120/240-volt transformer with a 1-turn fault when a $1^1/_2$x40-μsec wave is applied to the 7,200-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 9. Voltage across an impedance in the neutral of a 10-kva 2,400–120/240-volt transformer with no fault when a $1^1/_2$x40-μsec wave is applied to the 2,400-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 10. Voltage across an impedance in the neutral of a 10-kva 2,400–120/240-volt transformer with a 1-turn fault when a $1^1/_2$x40-μsec wave is applied to the 2,400-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period

impulses to the low-voltage windings of small pole-type distribution transformers. Testing circuits were used which would apply the proper crest voltages to the low-voltage winding and, by controlling the length of the applied wave, induce the proper voltage on the high-voltage winding. The induced-voltage wave, viewed on a cathode-ray oscillograph, was used to detect failures.

Because early data indicated the importance of a searching test on the transformer low-voltage windings, this test is included in the quality-control impulse testing of distribution transformers.[3] As in the previous test, the induced-voltage wave is observed by means of the cathode-ray oscillograph, and thousands of tests have shown that it is a very sensitive and reliable method of detecting failures.

To show the sensitivity of this method of fault detection, simulated faults were made by wrapping one turn of insulated wire around the outer transformer winding. This turn is loosely coupled to both high- and low-voltage windings. Because of the loose coupling, the fault is harder to detect than a 1-turn fault buried in either winding. Many tests have been made to verify this statement. Consequently the changes in waveshape shown in the oscillograms are somewhat smaller than would be the case when the smallest failure occurs in the transformer itself. The turn faults referred to in the succeeding paragraphs refer to these simulated turn faults.

The oscillogram shown in Fig. 1 is the voltage wave induced on the high-voltage winding of a transformer rated 10-kva 7,200–120/240 volts when a 0.5x1.5-μsec wave is applied to the low-voltage winding. Fig. 2 shows this induced voltage wave when there is a 1-turn fault in the transformer. In like manner Fig. 3 shows the voltage wave induced on the high-voltage winding of a transformer rated 10 kva 2,400–120/240 volts when a 0.5x1.5-μsec wave is applied to its low-voltage winding. Fig. 4 shows this induced voltage wave when there is a 1-turn fault in the transformer. A comparison of Fig. 2 with Fig. 1 and of Fig. 4 with Fig. 3 will illustrate the sensitivity of this method of fault detection when tests of this type are made on small distribution transformers.

COMPARISON OF FAULT-DETECTION METHODS WHEN TESTING HIGH-VOLTAGE WINDINGS

In 1944 the method of observing the voltage induced on a winding other than the one under test was studied and compared to several other methods of fault detection.[6] It was found to be fairly sensitive in detecting distribution transformer faults when a $1^1/_2$x40-μsec impulse was applied to the high-voltage winding and the voltage induced on the low-voltage winding was observed by means of the cathode-ray oscillograph. However, the neutral impedance method of failure detection proved to be far more sensitive for this application and consequently has been used almost exclusively.

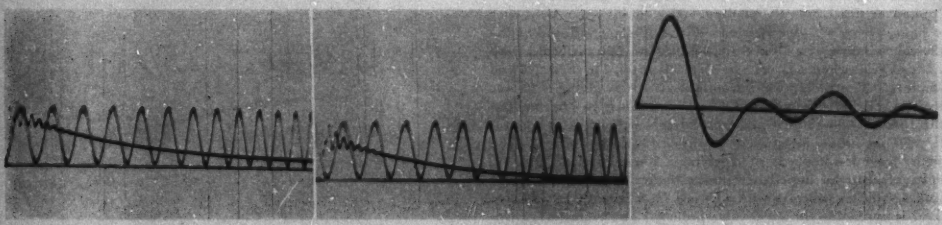
The relative sensitivities of the two methods are illustrated by Figs. 5 to 12, inclusive. Fig. 5 is the voltage wave across an impedance between the ground and the neutral of a transformer rated 10 kva 7,200–120/240 volts when a $1^1/_2$ x40-μsec wave is applied to the high-voltage winding. Fig. 6 shows this voltage wave when there is a 1-turn fault in the transformer. Fig. 7 shows the voltage wave induced on the low-voltage winding of this transformer when a $1^1/_2$ x40-μsec wave is applied to the high-voltage winding and Fig. 8 shows the same voltage wave when there is a 1-turn fault in the transformer.

Fig. 9 is the voltage wave across an impedance between ground and the neutral of a transformer rated 10 kva 2,400–120/240 volts when a $1^1/_2$x40-μsec wave is applied to the high-voltage winding. Fig. 10 shows this voltage wave when there is a 1-turn fault in the transformer. Fig. 11 shows the voltage wave induced on the low-voltage winding of this transformer when a $1^1/_2$x40-μsec wave is applied to the high-voltage winding and Fig. 12 shows the same wave when there is a 1-turn fault in the transformer. A comparison of these oscillograms will show that the neutral impedance method is the more sensitive of the two.

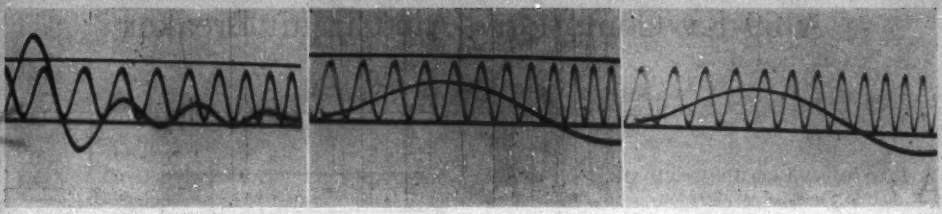
IMPULSE TESTING LOW-VOLTAGE WINDINGS OF LARGE HIGH-VOLTAGE DISTRIBUTION TRANSFORMERS

Another important group of distribution transformers are those used to step down subtransmission voltages to

Fig. 11. Voltage induced on the 120-volt winding of a 10-kva 2,400–120/240-volt transformer with no fault when a $1^1/_2$x40-μsec wave is applied to the 2,400-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 12. Voltage induced on the 120-volt winding of a 10-kva 2,400–120/240-volt transformer with a 1-turn fault when a $1^1/_2$x40-μsec wave is applied to the 2,400-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 13. Voltage across an impedance in the neutral of a 333-kva 67,000–7,200-volt transformer with no fault when a 1.5x27-μsec wave is applied to the 7,200-volt winding. The timing wave is omitted but the sweeping speed is the same as that used for the oscillogram shown in Fig. 15



11 12 13



14 15 16

Fig. 14. Voltage across an impedance in the neutral of a 333-kva 67,000–7,200-volt transformer with a 1-turn fault when a 1.5x27-μsec wave is applied to the 7,200-volt winding. The timing-wave frequency is 10 kc, giving a 100-μsec period. Fig. 15. Voltage induced on the 67,000-volt winding of a 333-kva 67,000–7,200-volt transformer with no fault when a 1.5x27-μsec wave is applied to the 7,200-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period. Fig. 16. Voltage induced on the 67,000-volt winding of a 333-kva 67,000–7,200-volt transformer with a 1-turn fault when a 1.5x27-μsec wave is applied to the 7,200-volt winding. The timing-wave frequency is 50 kc, giving a 20-μsec period

distribution voltages. Many of these are single-phase transformers, usually 100 to 500 kva with 22- to 66-kv primaries and 2.4- to 15-kv secondaries. In testing the secondary windings of these transformers many of the same problems are encountered as when testing the smaller pole-type transformers. However, the physical spacings between windings are much greater because of the insulation requirements, and the induced voltage waves on the high-voltage windings are not nearly so sensitive to faults as is the case for the small low-voltage transformers. Consequently, it may be desirable to use other fault-detection methods when testing this type of transformer.

Waves of fairly long duration can be applied to the low-voltage winding of this type of transformer without overstressing the high-voltage winding, even with its terminals isolated, and it is possible to use the neutral impedance method of fault detection. For this type of transformer, the oscillograms of Figs. 13 to 16 inclusive compare the relative sensitivities of the neutral impedance and induced-wave method of fault detection.

Fig. 13 is the voltage wave across an impedance between ground and the neutral of a transformer rated 333 kva 67,000–7,200 volts when a 1.5x27-μsec wave is applied to the low-voltage winding. Fig. 14 shows this same voltage wave when there is a 1-turn fault in the transformer. Fig. 15 is the voltage wave induced on the high-voltage winding of this transformer when the 1.5x27-μsec wave is applied to the low-voltage winding. Fig. 16 is the induced-voltage wave when there is a 1-turn fault in the transformer. In this case the induced-voltage wave changes very little when failure occurs and it is doubtful if a 1-turn failure could be detected using this method. The voltage wave across the neutral impedance clearly shows that failure has occurred. This indicates that, when it is possible to apply a voltage wave of this duration, the neutral impedance method of fault detection is the preferable method. It may still be the preferable method when waves of shorter duration are used, but further investigation is required to determine the minimum wavelength that will permit the use of the neutral impedance method.

CONCLUSIONS

1. In impulse testing of many ratings of distribution transformers having relatively high turn ratios, the standard $1^1/_2$x40-μsec wave cannot be applied between terminals of the low-voltage winding because excessive voltages would be induced in the high-voltage winding.

2. The magnitude of the voltage induced in the high-voltage winding can be held within limits by reducing the duration of the voltage wave applied to the low-voltage winding. Therefore, the use of voltage waves of shorter duration than $1^1/_2$x40 μsec is recommended as an effective means for impulse testing the low-voltage windings of such transformers.

3. A voltage wave of short duration applied to the low-voltage windings of distribution transformers is an effective test for weeding out defective transformers.

4. A voltage wave of 1- or 2-μsec duration is representative of the higher voltage surges applied to the transformer low-voltage winding terminals in service.

5. When short-duration voltage waves are applied to the low-voltage winding, observation of the voltage wave-shape induced in the high-voltage winding provides a very sensitive method of detecting faults in transformers with high-voltage ratings 15 kv and below.

6. For transformers with high-voltage ratings above 15 kv, further investigation is required to determine whether the induced voltage detection method will have sufficient sensitivity or whether other methods, such as the neutral current or the applied voltage methods, should be used.

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A 69-Kv Compressed-Air Circuit Breaker

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A 5,000,000-KVA COMPRESSED-AIR circuit breaker that is rated at 69,000 volts with 2,000-ampere continuous current-carrying capacity has been developed and tested. The breaker is completely metal enclosed. Six condenser bushings extend through the roof for mounting of current transformers, potential devices, and for connection to the customer's bus structure (Fig. 1). Verification tests included interrupting demonstrations at 66, 44, and 22 kv. Tests with varying rates of rise of the transient recovery voltage were also included in the testing program.

A series of single-pole tests were made with the breaker ungrounded, as well as grounded, at test voltages of 66, 44, and 22 kv. Currents measuring from 49,000 to 51,000 amperes at 22 kv were interrupted on both grounded and ungrounded circuits. This is the equivalent of between 5,800,000 and 6,100,000 kva at 69 kv. The maximum laboratory current available at 66 kv, which measured 25,000 amperes, was also interrupted.

The next series of tests was made with varying rates of rise of the transient recovery voltage. It can be shown that the maximum rate of rise of recovery voltage that will appear across the breaker lower orifice is determined by the breaker shunting resistor, when the breaker is applied on a circuit of a given short-circuit capacity. Therefore, the application of this breaker may be determined on a laboratory circuit producing rates of rise-of-recovery voltage exceeding those encountered in actual service. Tests employing various values of capacitive reactance shunting the breaker lower orifice, as well as different values of resistors shunting the orifice, were made with the object of obtaining high rates of rise of the test-circuit recovery voltage.

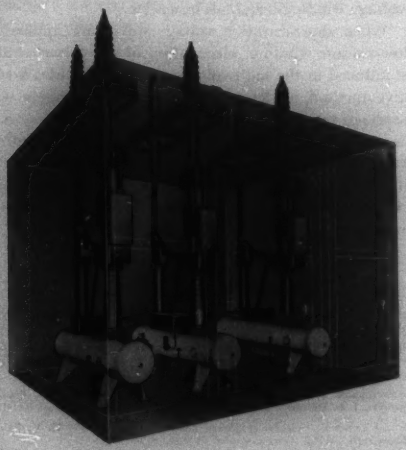

Fig. 1. 69-kv compressed-air circuit breaker

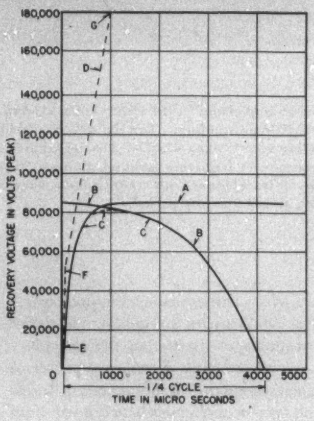

Fig. 2. Dielectric strength for 5,000,000-kva compressed-air circuit breaker

It should be noted that control of any circuit is taken over by the breaker because of the shunting resistor. Fig. 2 shows the relationship between the rate at which the breaker recovers dielectric strength (curve *D*) and the maximum rate at which any 69-kv 5,000,000-kva circuit with a 12-ohm resistance-shunted breaker can apply voltage to the breaker terminals (curve *C*). It should be noted that at any time after current zero, if curve *D* lies to the left and above curve *C*, the arc cannot be re-established since the voltage applied by the circuit will not be sufficient to cause breakdown through the dielectric strength developed within the breaker. Points *E* and *F* on curve *D* were obtained from high-current interrupting tests while point *G* was determined from voltage withstand tests made on an interrupter when not interrupting current. Point *G* is valid because its time relationship is such that deionization has already taken place. Curve *A* is the calculated recovery voltage for a 69-kv 5,000,000-kva ungrounded circuit with a 12-ohm resistance-shunted breaker. Curve *B* represents the circuit voltage for the first quarter cycle following arc extinction. Curve *C* results from subtracting the ordinates of curve *B* from 85,000 volts (69 kv $\times \sqrt{2} \times$ 87 per cent), and then subtracting this difference from the ordinates of curve *A*.

Successful interruption of 5,000,000 kva with an ample margin of safety has been demonstrated on both grounded and ungrounded circuits with rates of rise of recovery voltage much higher than any known field circuit.

Digest of paper 55-218, "A 69-Kv Compressed-Air Circuit Breaker for 5,000,000 Kva," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Intermittently Increased Kilovar Output

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RECOMMENDATIONS HAVE BEEN MADE by the AIEE for permissible 60-cycle overvoltage operation of power capacitors. Operation at overvoltage of capacitors means an increased kilovar output proportional to the square of the voltage increase. So far, little use has been made of the economics offered by this overload capacity. The overload capacity of capacitors can be used advantageously for two temporary system requirements: (1) a short-time comparatively large kilovar increase for system stability in emergency cases; and (2) a longer-time comparatively small kilovar increase for intermittent extreme-voltage or power-factor improvement.

Two methods for applying an overvoltage on all or part of the capacitors of a large bank are described. Both methods are similar in that they are applicable only to multiseries group capacitor banks. Under certain conditions both methods can be of great economic advantage since a temporary kilovar increase is accomplished only by the addition of a few small capacitor switches.

The principle of the series-short-circuiting method (Fig. 1) is to have one or more series groups in all three phases temporarily short-circuited, preferably the ones closest to the neutral. By short-circuiting some but not all series groups of a multiseries group capacitor bank, higher than normal voltage is applied across the remaining series groups which results in an increased kilovar output of the whole bank. The cost of this extremely simple kilovar increasing method is very small and is composed only of the cost of some small 15-kilovar capacitor switches, maybe some in-rush current-limiting reactors, and possibly some insulating transformers for the control of the switches.

The kilovar increase is shown as a function of the number of series groups with that of short-circuited series groups as a parameter in Fig. 2. With the series-short-circuiting method, the ratio of the kilovar increase above rated kilovar is the same as the increase in voltage above rated voltage of the series groups which are not short-circuited. The square relationship between kilovar increase and voltage increase is lost for the bank as a whole because the short-circuited series groups do not produce any kilovars.

The principal idea of the series-parallel method (Fig. 3) is to switch in parallel two series groups which normally are in series, so that double rated voltage is applied on all capacitors. Therefore, the kilovar output is four times rated kilovar. This scheme is especially effective for increasing the system stability for a short emergency period. Its advantage over the series-short-circuiting scheme is that all capacitors contribute to the increased kilovar, but its disadvantage is the larger number of switches required as well as a more complicated scheme in general.

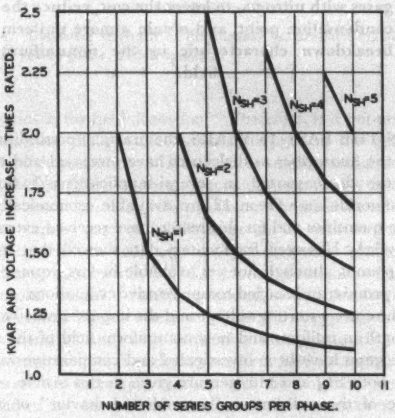

Fig. 2. Series-short-circuiting method kilovars increase

N_{SH} = *Number of short-circuited series groups per phase*

Neither of these methods is in use now, but it is hoped that now some interest will be aroused among the electric companies to utilize every dollar's worth out of a capacitor bank.

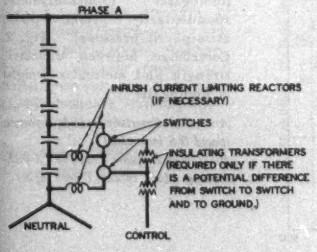
PHASE A
INRUSH CURRENT LIMITING REACTORS (IF NECESSARY)
SWITCHES
INSULATING TRANSFORMERS (REQUIRED ONLY IF THERE IS A POTENTIAL DIFFERENCE FROM SWITCH TO SWITCH AND TO GROUND.)
NEUTRAL
CONTROL

Fig. 1. Series-short-circuiting method

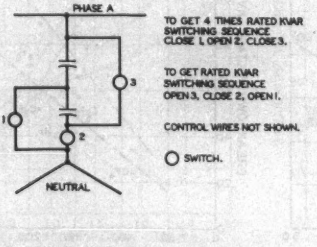
PHASE A
TO GET 4 TIMES RATED KVAR SWITCHING SEQUENCE CLOSE 1, OPEN 2, CLOSE 3.
TO GET RATED KVAR SWITCHING SEQUENCE OPEN 3, CLOSE 2, OPEN 1.
CONTROL WIRES NOT SHOWN.
SWITCH.
1
2
3
NEUTRAL

Fig. 3. Series-parallel method

Digest of paper 55-356, "Intermittently Increased Kilovar Output of Large Capacitor Banks," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Southern District Meeting, St. Petersburg, Fla., April 13–15, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

P. M. Minder is with Line Material Company, South Milwaukee, Wis.

Dielectric Behavior of Some Fluorogases and Their Mixtures With Nitrogen

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Preliminary evaluations of new fluorogases indicate that the dielectric characteristics of many of the new fluorocarbons are superior to those of the halogenated gaseous compounds. However, it is often advantageous to mix these gases with nitrogen to lower the cost, reduce the condensation point, and obtain a more uniform breakdown characteristic in the nonuniform field.

IN THE LAST 15 YEARS, the practical possibilities of the fluorogases as dielectrics have increased and their use demonstrated in several applications.[1,2] Sulfur hexafluoride and Freon 12 are available economically in large quantities and for this reason have received extensive study.[3–5] However, fragmentary data showed that many compounds although not yet available in large quantities, held promise and needed comprehensive evaluations.

The corona starting voltage and the impulse and 60-cycle strength in uniform and in a nonuniform field of the new fluorogases have been investigated and comparative values with both SF_6 and nitrogen are given in this article. Because of the well-known "anomalous behavior" of electronegative gases, the strength of these fluorogases in a nonuniform field begin to drop in a certain region of pressures. It was found possible to shift this region for practical purposes to a higher pressure range by mixing the gases with nitrogen. Additional benefits of this procedure also were realized in lowering total gas cost and condensation temperature which is very desirable for outdoor applications. These advantages resulting from mixing nitrogen should find radical applications.

The test cell made of a Plexiglas cylinder of 8-inch inside diameter with herkolite end plates was used. Two sets of test electrodes were chosen to simulate the fairly uniform field and the nonuniform field conditions often encountered in an electric apparatus. The former consists of 3-inch-diameter chrome-plated planes with rounded edges. The other set consists of a 1/4-inch-square aluminum rod and a 3-inch-diameter grounded plane. The electrode spacing was adjusted by means of a micrometer connected to one of the electrodes.

Before each fluorogas was admitted into the cell, the cylinder was first washed with soap and water, rinsed with distilled water, and dried in an oven. After the cylinder was assembled in place, the cell was evacuated two times between which it was flushed with the test gas. Then the test gas was admitted to the desired pressure for test.

During the 60-cycle breakdown voltage tests, the voltage

Revised text of conference paper CP55-251 presented at a session of the AIEE Committee on Basic Sciences, AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955.

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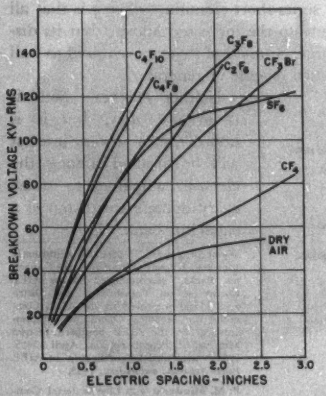

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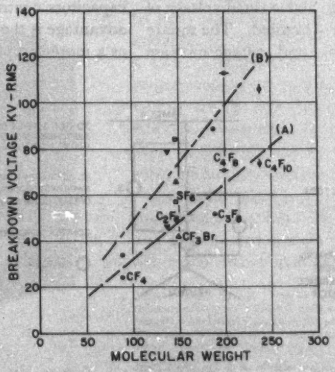

2

Fig. 1. 60-cycle strength of fluorogases (3-inch-diameter round-edged plane-to-plane atmospheric pressure). Fig. 2. Correlation between dielectric strength and molecular weight of fluorogases

A—3-inch-diameter round-edged planes, spaced 0.5 inch apart
B—1/4-inch-square rod to 3-inch-diameter plane spaced 1 inch apart

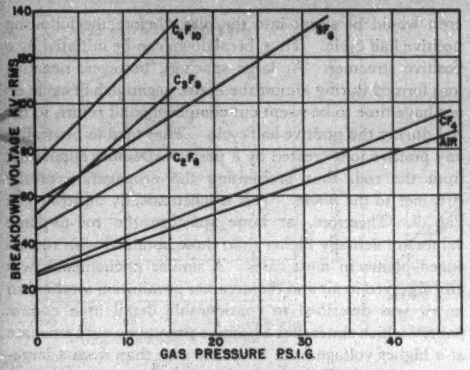

Fig. 3. Dielectric strength of fluorogases vs. pressure (3-inch diameter round-edged plane-to-plane, 1/2-inch spacing)

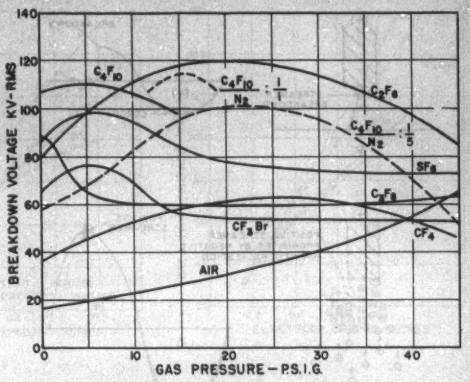

Fig. 4. Dielectric strength of fluorogases vs. pressure (1/4-inch-square rod-to-plane, 1-inch spacing)

was raised at a rate of about 1 kv per second until breakdown occurred. For corona tests the voltage was raised at a slower rate, but in neither case was the rate of rise found to be critical. During impulse tests the voltage was increased in approximately 10-per-cent steps and one 1.5x50-microsecond impulse was applied at each step until breakdown occurred. Three breakdown values were taken for each gap spacing for either type of voltages.

DIELECTRIC STRENGTH OF FLUOROGASES

THE DIELECTRIC STRENGTH of fluorogases is, in general, much higher than that of air. The breakdown voltages vs. electrode spacing with a pair of 3-inch-diameter round-edged planes are plotted in Fig. 1.

It is seen that the slopes of the curves are not alike for the various gases, especially at large spacings. This is attributed to the deviation from uniform field at the electrode edges for such spacings, and the different reactions of the gases to the field distortion. Therefore, it is not proper to compare the relative intrinsic strength of the various gases at those spacings. However, at small spacings where the field is fairly uniform, a comparison of the relative strengths can be made. By plotting the breakdown voltages of the various gases at 1/2-inch spacing vs. their molecular weights, one can conclude that the dielectric strength of the gases, as shown in Fig. 2*A*, increases roughly with the molecular weight. Similar relationship was also found in hydrocarbon liquids where the dielectric strength increases with density[6] and with molecular chain length.[7] It is interesting to note that the nonuniform field strength of the gases seem to increase even faster with the molecular weight, as shown by curve *B* of the same figure. However, this relationship should not be generalized at this time.

The dielectric strength of these gases has also been determined at pressures higher than atmospheric. The linear increase with pressure, shown in Fig. 3, is in accord with

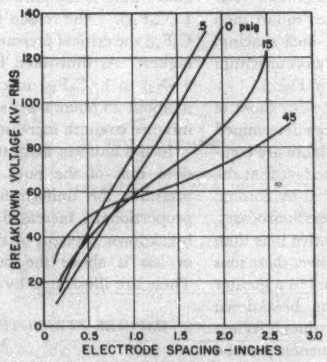

Fig. 5. 60-cycle strength of CF_3Br with 1/4-inch-square rod-to-plane gap at several pressures.

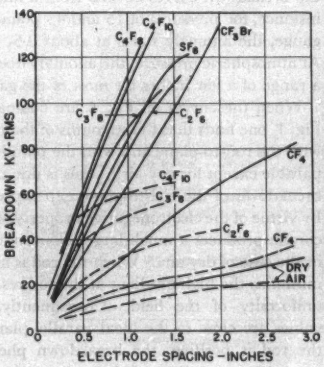

Fig. 6. 60-cycle corona and breakdown voltage of fluorogases (1/4-inch-square rod-to-plane—atmospheric pressure).

Solid curves—breakdown
Dashed curves—corona

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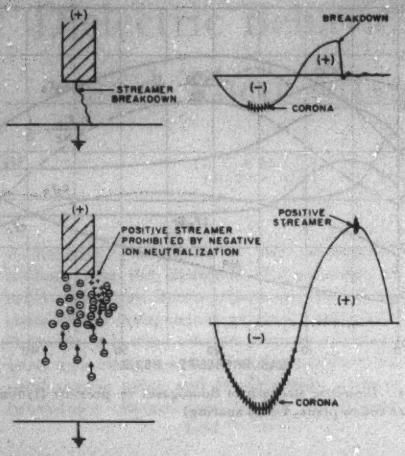


Fig. 7. Schematic diagram showing ion distribution in rod-to-plane gaps

Paschen's law. However, the small difference in slope for the various gases is not clear. This pressure dependence has been utilized in gas-insulated apparatus[1,2,12] in which the electrode configurations give essentially uniform fields. However, it is well known that in nonuniform fields the strength of the electronegative gases actually decreases with increasing pressure in some region of pressures.[8] This anomalous behavior is possessed by all electronegative gases or a mixture of gases that contain an electronegative gas, such as O_2 in air.[9] For a 1-inch rod-to-plane gap, the anomalous behavior of some electronegative fluorogases is shown in Fig. 4. It is seen that the "critical pressure" at which the strength begins to drop is different for different gases.

For a specific gas this anomaly can also be observed by plotting the strength of the gas vs. electrode spacing such as shown in Fig. 5. It is seen that this anomaly occurs when the breakdown curves deviate from a linear increase. For instance, for pressures of 15 and 45 pounds per square inch gauge, the anomaly starts at about 0.5- to 1-inch spacing. At atmospheric pressure, the anomaly does not occur within a range of a few inches for most of the gases in Fig. 6.

When the curves on Fig. 6 are compared with those of Fig. 1, one finds that the strengths of these gases determined with the rod-to-plane and with the parallel planes are comparable except for dry air. This is due to the fact that the breakdown of the rod-to-plane gap is preceded by corona. By virtue of the electronegative property of these fluorogases, corona produces a much larger cloud of negative ions than in the case of dry air. When the rod is negative, these ions minimize the high gradient at the rod resulting in a greater uniformity of the field. Consequently, the breakdown values are close to the ideal parallel-plane values. When the rod is positive, the breakdown phenomenon can be treated in two regions of electrode spacing. At small spacings, negative ions formed at the rod during negative voltage crest would be swept into the plane before the following positive half cycle. Thus, breakdown can be initiated by a positive streamer. At large spacings, however, negative ions formed during almost the entire negative half cycle do not have time to be swept out completely and return to the rod during the positive half cycle. They tend to neutralize any positive ions created by a positive streamer emanating from the rod, thus prohibiting the propagation of the streamer to the plane. This is schematically illustrated in Fig. 7. Therefore, at large spacings the rod-to-plane values are actually higher than those obtained with round-edged planes in most cases. A similar phenomenon was also observed in air and the streamer prohibition mechanism in air was described in considerable detail in a corona paper[10] which states that a positive streamer would emanate at a higher voltage from a smaller wire than from a large-diameter one. This phenomenon often appears contrary to the common experience in that rounded electrodes should result in a higher breakdown voltage than sharp electrodes.

The visual corona starting voltages for the various gases are shown by the dotted curves of Fig. 6. To avoid inconsistency of human eyes during the tests, a photocell incorporated with an amplifier and an indicating meter was used. A light-detection method was preferred because there was some minute corona in the test cell which confused the indication by conventional electrical detection methods.[11–14] It is conceivable that these corona values might be slightly higher than the actual corona starting voltages. The wide separation of corona and breakdown values are often referred to as due to "corona stabilization."

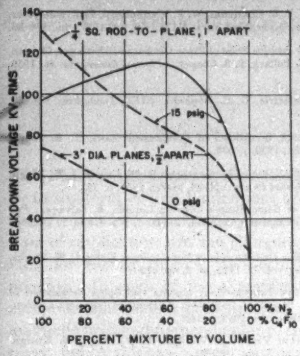
DIELECTRIC STRENGTH OF MIXTURES OF FLUOROGASES AND NITROGEN

In searching for a means to avoid the anomalous behavior of the fluorogases with nonuniform field, nitrogen was mixed with C_4F_{10} in various proportions. It was extremely interesting to find that at 15 pounds per square inch gauge while the breakdown voltage of pure C_4F_{10} had dropped below 100 kv, Fig. 4, a 1-to-1 mixture actually yielded a higher strength. This is also shown by the solid curve in Fig. 8. It is seen that the strength is maintained above that of the pure C_4F_{10} up to a mixture of 5 (N_2) to 1 (C_4F_{10}). The reason for this is that as N_2 is mixed into C_4F_{10}, the critical pressure of the anomalous region becomes higher. As illustrated by the dotted curves in Fig. 4, a 5 (N_2) to 1 (C_4F_{10}) mixture will shift the critical pressure to about 25 pounds per square inch gauge below which the mixture strength increases with pressure as a normal gas.

In the uniform field, the strength of the mixture is lower than that of the pure gas. However, by using higher pressures the uniform-field strength for the mixtures is proportionally increased. For instance, at 15 pounds the breakdown strength of the mixture of 4 (N_2) to 1 (C_4F_{10}) or less is above the pure gas at atmospheric pressure. These are illustrated by the broken curves in Fig. 8.

IMPULSE STRENGTH OF FLUOROGAS–NITROGEN MIXTURES

Data on the impulse breakdown characteristics of the insulating gases are pertinent when they are used in



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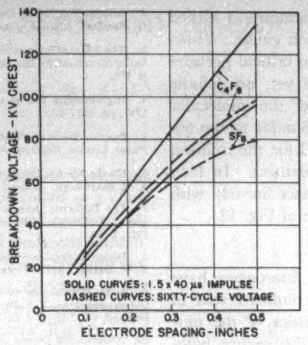

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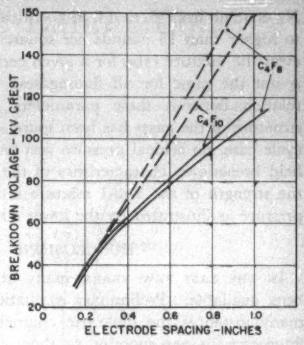

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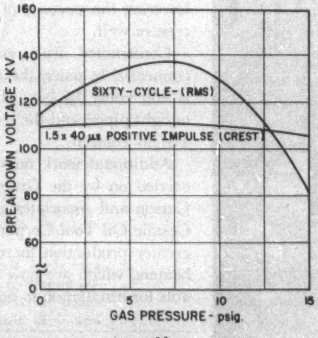
Fig. 8. 60-cycle strength of mixtures of C_4F_{10} and N_2. Fig. 9. Comparison of impulse and 60-cycle breakdown characteristics of fluorogases (3-inch-diameter round-edged plane-to-plane, atmospheric pressure). Fig. 10. Comparison of impulse and 60-cycle breakdown characteristics of fluorogases (1/4-inch-square rod-to-plane gas—atmospheric pressure): *Solid curves for 5(N_2) to 1(C_4F_{10}) mixture; dashed curves for 14(N_2) 1(C_4F_{10}) mixture*

apparatus that is liable to be exposed to lightning or switching surges. It is expected that the difference in impulse strengths of various gases in a quasi-uniform field should be comparable to the difference of their 60-cycle strengths because of the lack of corona prior to breakdown. This is illustrated in Fig. 9. The curves show that the impulse strength of C_4F_{10} is higher than that of SF_6 by an amount comparable to the difference of their 60-cycle strengths. The impulse ratio (impulse to 60-cycle crest strength) is higher than unity.

However, when the gases are tested with a nonuniform field (rod-to-plane) gap, a given gas might have a higher 60-cycle strength but a lower impulse strength when compared with another gas. This is illustrated by Fig. 10. From the figure it can be seen that the impulse ratios are consistently less than unity, except perhaps at the small spacings where the field is less nonuniform. These anomalous characteristics are attributed to the presence and intensity of corona prior to breakdown and the resulting space charge which varies for different conditions. The difference of the corona or space-charge effect can be illustrated by plotting the strength of the gas with various pressures, as shown in Fig. 11. It is seen that neither the impulse nor the 60-cycle strength increases consistently with pressure as for an ideal gas. The anomaly is more pronounced in the 60-cycle case where the effect of corona or space charge is expected to be larger.

It has been shown previously that the addition of N_2 to the fluorogases effectively shifts the critical pressure to a higher value in the case of nonuniform field. This was found to be true also in the case of impulse voltages. For instance, in Fig. 12 the nonuniform field strength appears to start dropping slightly at about 10 pounds per square inch gauge for a 5-to-1 mixture. With further increase of



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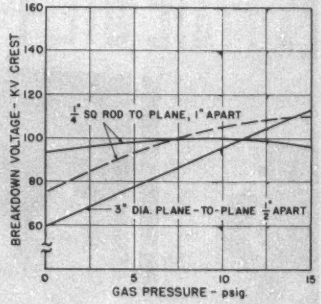

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Fig. 11. Effect of pressure on impulse and 60-cycle strengths of C_4F_8 (1/4-inch-square rod-to-plane gap—1-inch spacing). Fig. 12. Positive impulse strength of mixtures of C_4F_{10} and N_2

N_2 content from 5 to 14, the critical pressure is shifted to higher than 15 pounds per square inch gauge. However, the mixture ratio for a given certain critical pressure is not the same for all fluorogases. As yet, no definite relation between these parameters and the molecular structure of the gases has been found. Similar to the 60-cycle case, no critical pressure was found for the uniform field breakdown characteristics of the mixtures. In fact, the strength of the 5-to-1 mixture increases linearly with pressure as illustrated by the lower curve of Fig. 12.

CONCLUSIONS

In the last few years, many new fluorogases have been available. Preliminary evaluations indicate that in many instances the dielectric characteristics of the new fluorocarbons are superior to those of the earlier halogenated gaseous compounds. In some cases, however, it is desirable to mix these gases with nitrogen for the purposes of lowering the total cost of the gases, to reduce the condensation point of the pure fluorogases, and to obtain a more uniform breakdown characteristic in the non-uniform field.

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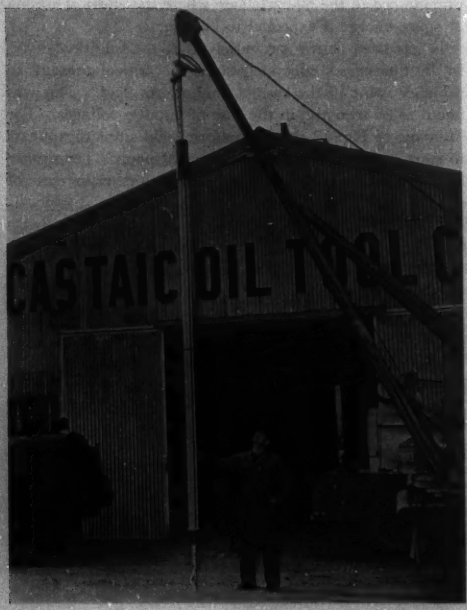
Electric Heater Increases Oil-Well Production



This 18-foot electric oil-well heater, which has been developed co-operatively by N. W. Curson and Associates and the industrial heating department of the General Electric Company, is being constructed by the Castaic Oil Tool Corporation. It has been increasing oil output as much as 900 per cent in low-producing wells. The electric heater was built for N. W. Curson and Associates, who report that on oil wells which formerly produced 5 barrels of oil a day, production has been increased to a maximum of 45 barrels a day. The increased production is the result of the faster rate of flow which is made possible by the heaters lowering the viscosity of the heavy sludgy crude oil in this type of well.

Constructed from six 80-inch Calrod* heater units connected in pairs, the total rating of the complete heater is 460 volts, 15 kw. The Calrod heaters are sealed in oiltight pipes, and the connections are brought up through a rigid conduit.

Additional work on oil-well heating problems is being carried on by the General Electric Company and N. W. Curson and Associates at the Newhall, Calif., plant of the Castaic Oil Tool Corporation. It is anticipated that even greater production increases will be effected when larger heaters, which are now under construction, become available for installation in other low-producing oil wells.

* Registered trade-mark of the General Electric Company

Compressional Stress on Magnetic Laminations

R. E. FISCHELL

IN MANY important applications, magnetic materials in the form of thin laminations are subjected to a compressional stress. Particularly important examples of this type of application are the clamping of magnetic laminations for electric motors, transformers, and synchro-components. In each of the examples, the direction of the compressional stress is perpendicular to the direction of the magnetic field and perpendicular to the plane of the laminations; hence, this case warrants special consideration.

Toroidal laminated specimens of ten different magnetic materials were tested. The specimens were 3.5-per-cent and 6.4-per-cent silicon-iron, 81-per-cent and 90-per-cent nickel-iron, and both hydrogen- and air-annealed samples of AEM 4750, 12 Alfenol and 16 Alfenol.

Two types of tests were made, and for each test the magnetic properties of the specimen were measured at transverse compressional stresses of 0, 100, 200, 300, 400, and 500 pounds per square inch (psi). The first of these tests was the standard d-c fluxmeter measurement of maximum permeability, remanence, coercive force, and near-saturation flux density as measured at a field of 30 oersteds. The second test was made with a-c fields at frequencies of 60 and 400 cycles per second (cps). The purpose of this test was to determine the effect of transverse compressional stress on the a-c magnetization curve and a-c hysteresis loop.

Some of the results of the a-c tests are shown in Figs. 1 and 2. Fig. 1 shows the effect of a compressional stress of 500 psi on the 60-cps hysteresis loop of the negative magnetostriction material, 90-per-cent nickel-iron. The observed result of a decrease in the rectangularity of the hysteresis loop at higher values of compressional stress was typical for all the materials tested which had nonzero magnetostriction. It should be noted that when the compressional stress is applied in the same direction as the magnetic field, materials having negative magnetostriction exhibit an increase in rectangularity rather than the decrease shown in Fig. 1. Fig. 2 shows that for the zero magnetostriction material, 6.4-per-cent silicon-iron, the compressional stress produces no noticeable change in the dynamic hysteresis loop.

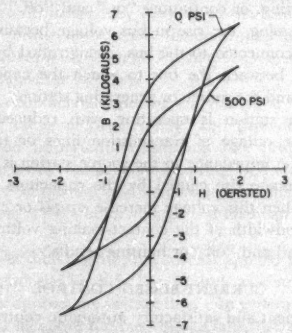


Fig. 1. Dynamic hysteresis loops at a frequency of 60 cps for hydrogen-annealed 90-per-cent nickel-iron at transverse compressional stresses of 0 and 500 psi

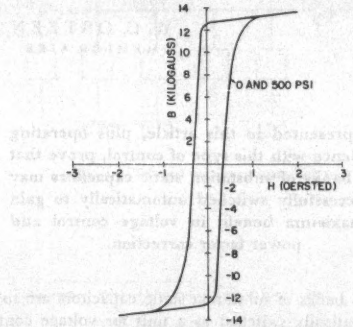


Fig. 2. Dynamic hysteresis loops at a frequency of 60 cps for 6.4-per-cent silicon-iron at transverse compressional stresses of 0 and 500 psi

From the results of the measurements on the ten materials tested, several conclusions can be drawn regarding the sensitivity of magnetic materials to a transverse compressional stress:

1. Variations in magnetic properties are dependent on the magnitude and not the sign of the magnetostriction.
2. For materials having nonzero magnetostriction, under the action of an increasing transverse compressional stress: (*a*) the maximum permeability decreased, (*b*) the coercive force increased, (*c*) the remanence decreased, (*d*) the flux density near saturation remained virtually unchanged, and (*e*) the maximum a-c flux density decreased.
3. The magnetic characteristics of materials having zero magnetostriction remain virtually unaltered by transverse compressional stress except at very low fields.

The results of this digest can be applied in choosing a magnetic material for a particular application where sensitivity to transverse compressional stress is an important design consideration.

Digest of paper 55-171, "Effects of Transverse Compressional Stress on Magnetic Laminations," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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Switching of Substation Capacitor Banks by Current-Biased Induction-Voltage Relay

W. C. OSTEEN J. J. McCULLOUGH
MEMBER AIEE

Data presented in this article, plus operating experience with this type of control, prove that large banks of substation static capacitors may be successfully switched automatically to gain the maximum benefit in voltage control and power factor correction.

IF large banks of substation static capacitors are to be automatically switched as a unit for voltage control and power factor correction, a control scheme is usually required that will respond to both voltage and current and is adjustable over a wide and accurate range.

This article discusses the development of such a scheme, utilizing a conventional single-phase voltage relay, modified by the addition of a current winding, or a dropping resistor to provide the required control.

A number of static capacitor banks, ranging in size from 720 to 2,640 reactive kilovolt-amperes, were installed at various distribution substations of 16 kv, 11 kv, and 4 kv for voltage and power factor control, and were connected as shown in Fig. 1. These static capacitors were to be switched automatically in a single unit, controlled by the station bus voltage, and becoming, in effect, a single-step voltage regulator.

The bus-voltage change or rise caused by static capacitors connected to a bus is independent of the load or power factor at the bus, or the load or power factor of the transformers directly supplying the bus. This bus-voltage rise or change is a direct function of the impedance between the distribution station bus and the source or transmission station, which usually includes transformer bank (or banks) and transmission line (or lines). The higher the impedance the greater will be the change or rise in bus voltage, and low impedance will produce less rise or change. A close approximation of this rise or change can be calculated by

$$\frac{\text{kvar}}{\text{TSC}} \times 100 = \text{Per cent of volts rise}$$

where TSC = total short circuit (kva) at station bus.

STRAIGHT VOLTAGE CONTROL

FOR automatic control of these substation static capacitors, a standard beam-type primary relay, or contact-making voltmeter, actuated from bus potential transformer was used. This type of straight voltage control proved unsatisfactory for the following reasons:

1. Bus-voltage change out-of-range of the contact-making voltmeter. At some locations, particularly those a considerable distance from the transmission or source station, the bus-voltage change or rise caused by the capacitor bank was found to be 5 volts or more. This 5 volts plus a necessary 3-volt clearance spread called for an 8-volt total bandwidth on the contact-making voltmeter, which made a difficult and inaccurate setting, as these relays are designed for a maximum accurate bandwidth of 6 volts; also a band spread of ±4 volts was too great for efficient use of the capacitor.

2. Not sufficient bus-voltage change between light- and heavy-load periods. At stations located near the source of supply the bus voltage is kept nearly constant by voltage regulation at the source station. A minimum bandwidth setting on the contact-making voltmeter would be out of range of the change in voltage. At heavy-load periods, even though voltage correction is not essential, the capacitor banks are very desirable for improving power factor and materially reducing transformer-bank amperes. The opposite would apply during light-load periods; that is, power factor may be leading with the capacitors "on" and switching the capacitor "off" would result in improved power factor and reduced bank amperes.

3. Hunting, or continuous "on" and "off." As stated in the foregoing, the rise in bus voltage because of static capacitors connected to the bus, is controlled by the total impedance between the bus to which the capacitors are connected and the source or generating station. When the distribution station is operating with reduced capacity such as the outage of transmission lines or transformer capacity, the impedance to the source station is increased, and bus-voltage rise caused by the capacitors would increase. When this voltage increase equals or exceeds the voltage bandwidth of the contact-making voltmeter, continuous "on" and "off" or hunting results.

CURRENT-BIASED CONTROL

FOR efficient and satisfactory automatic control of these substation capacitors, a relay was needed that would respond to both voltage and current, and also would have a bandwidth adjustable over a wide and accurate range.

To get the desired results a standard 115-volt single-phase induction disk-type relay, equipped with adjustable

Full text of conference paper CP55-17, "Automatic Switching of Substation Static Capacitor Banks by a Current-Biased Induction Disk-Type Voltage Relay," presented at the session of the AIEE Committee on Substations, AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955.

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contacts, was used. The adjustable contacts were single-pole double-throw, one for opening and one for closing the capacitor breaker.

A 14-turn hand-wound current coil was installed or wound over the outside of the potential coil, and connected to one phase of the secondary current used for total metering of the low-voltage bus load. (See Fig. 1.) The potential coil was connected to the 115-volt secondary of bus potential transformers, and this voltage was selected to lag the current applied to the relay by 30° at 1.0 power factor.

This type of relay (Fig. 2) is equipped with a spiral control spring for adjusting the torque required to move the disk, and this point can be varied from 12 volts across the potential coil to move the disk to 48 volts. A 2,000-ohm 25-watt variable resistor in series with the potential coil is used to adjust the potential-coil voltage drop. The potential coil is designed for 67 volts maximum continuous duty. A maximum setting of the control spring (48-volt drop across the potential coil to move the disk), with 5 amperes in the current winding, will make the relay more sensitive to current than to voltage; percentage-wise, about 80 per cent current and 20 per cent voltage. At a minimum control spring setting the relay is more voltage sensitive, about 30 per cent current and 70 per cent voltage.

Viewed from the front, the right-hand, or switch-closing, contacts of the relay are closed when no voltage exists across the relay potential coil. When sufficient voltage is applied to the potential coil, torque is developed which will move the disk to close the left-hand or switch-opening contacts. The amount of torque or voltage required to move the disk to the left-hand contacts is variable by the spiral control spring; that is, the tighter or more tension used on the control spring, the greater is the torque or voltage required to close the left-hand contacts. When the movable contacts, which are attached to the disk shaft, are held by voltage in the mid-point between the left-hand and right-hand contacts, then lower voltage or increased current (the current flux opposes the voltage flux) will allow the control spring to close the right-hand contacts which will close the capacitor breaker. Increased voltage and decreased current, assisted by leading power factor, will increase disk torque, overcoming the control spring, and the relay disk will move to close the left-hand contacts which will open the capacitor breaker.

The relay contacts for opening and closing are adjustable for a wide range of band spread and provide the most accurate and important adjustment. By proper adjustment of the series resistor, control spring, and contacts, any combination of current and voltage torque that meets the requirements of the station voltage and load can be applied to the relay.

At a power factor of 1.0, the current applied to the relay leads the potential by 30° (Fig. 3) and, as connected, this current flux opposes the voltage flux. In general, when the station load increases the bus voltage falls, the amperes increase, and the current moves in the lag direction as the power factor goes lower. These three conditions add to give less torque on the relay disk, and at a preset value the relay contacts make, closing the capacitor-bank circuit breaker. When the capacitor switch is closed there is a

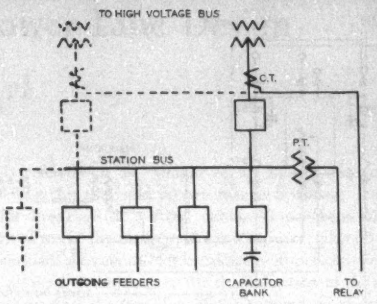

Fig. 1. Typical capacitor installation

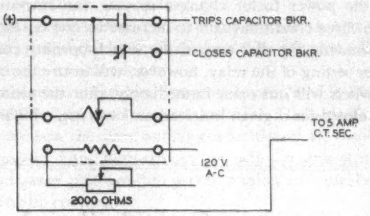

Fig. 2. Relay with biasing current coil

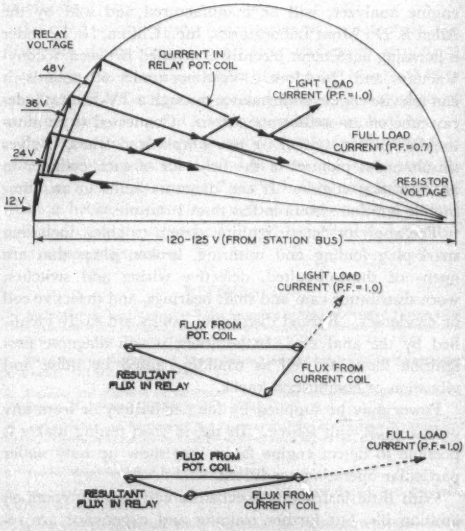

Fig. 3. Relay current and torque

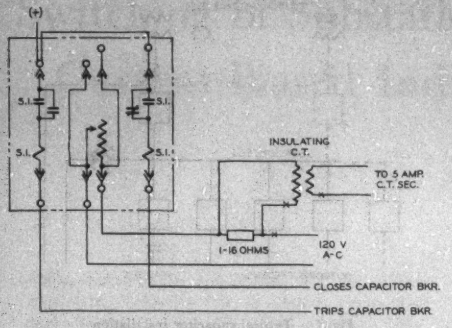

Fig. 4. Relay with biasing resistor

rise in bus voltage, a drop in transformer-bank amperes, and the power factor changes moving the current lead. These three conditions add to increase torque on the relay disk, moving the disk toward the switch-opening contacts. Proper setting of the relay, however, will insure the capacitor switch will not open immediately after the switch has been closed for a given bus load and voltage. Further increase in bus load will, of course, move the disk back toward the switch-closing position. When bus load decreases to a preselected condition, increased relay disk torque caused by voltage rise, current drop, and power factor change will open the capacitor circuit breaker.

A second scheme was successfully developed using a relay similar to the one described in the foregoing, except that no resistor in series with the potential coil or added current winding is used. This type of relay has a potential coil designed for +120 volts.

An 85-watt dropping resistor variable from 4.7 to 18.8 ohms is installed in the potential circuit, and the single-phase current is connected across this dropping resistor. (See Fig. 4.) A 3-to-1-ratio instrument current transformer is connected between the current source and the dropping resistor. This 3-to-1-current transformer reduces the primary current transformer's burden over what would be required by connecting directly across the dropping resistor; it also provides an isolated current source that is free of ground and can, in all conditions, be connected to the potential supply through the dropping resistor.

The same conditions of power factor, voltage, current, and adjustments apply to this relay with the dropping resistor as were described for the relay using a current winding over the potential coil.

Cathode-Ray Analyzer to Aid Auto Repair

An electronic instrument for quick and accurate diagnosis of automotive engine ills, has been developed in the research laboratories of Socony-Vacuum Oil Company. The device, listed as the Du Mont type *907* cathode-ray engine analyzer, will be manufactured and sold by the Allen B. Du Mont Laboratories, Inc., Clifton, N. J., under a licensing agreement recently concluded between Socony-Vacuum and Du Mont. Weighing under 60 pounds, it can televise engine performance through a TV-like cathode-ray tube on an oscilloscope screen. Connected to an automobile ignition system by two simple lead wires, it gives simultaneous pictures of the behavior of each cylinder in an operating engine. It can diagnose faults in an automobile ignition system in less than 1 minute.

The analyzer detects ignition system troubles, including spark-plug fouling and misfiring, broken plugs that are open- or short-circuited, defective wiring and switches, worn distributor cam and shaft bearings, and defective coil or condenser. Burned distributor points are easily identified by the analyzer. In addition, it will diagnose pre-ignition faults as well as troubles caused by noise and vibration or combustion knock.

Power may be supplied by the car battery or from any ordinary 110-volt source. Its use in road testing makes it possible to detect engine faults that show up only under particular operating conditions.

With little instruction mechanics can identify common ignition ills, but further training and experience are required to recognize obscure engine troubles.

The engine analyzer was invented by Albert E. Traver, electronics engineer at Socony-Vacuum's Technical Service Laboratories, Brooklyn, N. Y. Development work was conducted by J. Howell Goffe, research associate at the company's Research and Development Laboratories, Paulsboro, N. J.

European Practices in Power-Line Design

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THIS digest presents a review of wind, ice, and other loading assumptions specified by European line designers, so as to draw a comparison between American assumptions and those employed abroad.

A comparison of wind speeds employed by European designers[1] is not conclusive of tower loadings because of the differing coefficients in the pressure formula $P=KSV^2$. The variations lie in the reduction multipliers for cylinders and not in the coefficient for flat surfaces. In this country a multiplier of 0.5 is used for bare and iced cables alike, while in Europe the multipliers vary from 0.4 to 0.7.

Wind pressure on towers is generally based on the maximum wind speed anticipated. The peak velocity of a squall has a relatively narrow front; thus a tower might get the full blast. However, the mean velocity over a long span is considerably less than the peak anticipated. It was found in Swedish tests[2] that average wind velocity of an entire span was 60 per cent of the maximum velocity. As a result of this investigation and their K factor of 0.6, they specify 5.1 pounds per square foot as unit wind pressure on iced cables.

A corollary to reduced wind pressures on wires is the resulting smaller swing angles of insulator strings toward the tower. Several countries[3] are presently giving this their attention because it will permit upgrading or increasing the voltage use of existing lines if more units can be added to the string, and it will reduce the cost of new lines.

Most countries of Europe include in their designs[1] an allowance for the accumulation of ice on conductors. There are those who add 0.47 radial inch; and those who add a constant weight, 1.34 pounds per foot, without regard to the cable size. When special ice formations are specified they are applied as vertical loads to determine wire tensions at angles and dead ends, and not coincident with wind and broken wire loads.

The European countries[4] which take into account the longitudinal pull of a conductor are of four groups, those who combine: (1) wind and broken wire forces, as Germany; (2) ice and broken wire forces, as Sweden; (3) wind, ice, and broken wire forces, as Great Britain, Belgium, and Norway; and (4) wind, ice, and a longitudinal pull for unbalance in conductor tensions caused by uneven wind and ice loadings, as in Italy and Switzerland.

The Swedish design practice[5] is worthy of consideration. For conductor pulls at corners and dead ends, they compute the resultant of their assumed wind and ice load, which value is referred to as "weight of ice in the absence of wind." To this they add 30 per cent as overload. In designs for breakage of a fixed cable, 60 per cent of the "weight of ice in the absence of wind" is used, plus 30-per-cent overload. For conductor breakage a 50-per-cent reduction is allowed to compensate for the deflection of the insulator string and the bending of the support or crossarm. Thirty-nine-hundredth of the design tension is the broken conductor load at the tower elastic limit used on their 400-kv line.

There is general agreement in Europe that the supposition of a broken wire should be questioned, particularly when applied to high-voltage lines with large conductors. Conductor failures are indeed rare and, if they are considered as being possible, Europeans say that a unit stress near the structure elastic limit should be adopted without the inclusion of other loads.

Several structural design features are practiced in Europe, which differ from American procedures. High-tensile steel towers are now the usual as four grades of steel are available. Different-sized and high-strength bolts in the same structure to avoid gusset plates and to permit smaller structural members are also common.

A subject, on which there seems to be agreement in Europe but which is treated here quite differently, is the torque distribution from a broken conductor at the end of a crossarm. The British treatment of rectangular towers, as described by A. E. Percivall,[6] is to consider the crossarm as a rigid beam with the torsional reaction taken entirely by the longitudinal faces.

To effect a uniformity for comparison, whether or not European design requirements lead to heavier structures than ours, the Peterson empirical formula[7] $W=\mathrm{He}\sqrt[3]{P^2}$ is employed to arrive at an estimated weight for the towers of each country, using the loading conditions applicable.

For American towers, a range of calculated weights is offered using 8 pounds of wind as cross-line load acting on radial ice formations from 1/2 to 1 1/2 inches, coupled with or without broken conductor conditions and with the several overload capacity factors employed by utility and government agency designers.

Digest of paper 55-149, "Investigation of European Practices in Power-Line Design," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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The author in the fall of 1953, while an engineer for the Pennsylvania Water and Power Company, visited nine countries of Europe where he lectured in nine cities. The author is indebted to the many European engineers who contributed much of the material from which this article is drawn and with whom he discussed the common problem of economic line designs.

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Transistor Demodulator for Magnetic Amplifiers in A-C Servo Applications

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A phase-sensitive transistor demodulator in series with the high-gain 2-stage magnetic amplifier, as described, provides a unit that is very effective in a position servo system.

FULL-WAVE magnetic amplifiers are not efficiently controlled with a-c signals applied directly to the control windings because the circuit configurations necessary do not give sufficiently high gain. Half-wave magnetic amplifiers, which can accept a-c signals directly, have relatively low gain. The most sensitive stable magnetic amplifiers require a d-c control current, but in many servo applications the servo amplifier must accept a phase-reversible a-c signal and deliver an output that will reverse phase as the phase of the input signal reverses.

An ideal solution to the a-c input problem is obtained by inserting a phase-sensitive demodulator in series with the magnetic-amplifier control windings. Such a demodulator, however, must have good balance characteristics over a wide temperature range, and its transfer curve must be linear even at low-voltage levels. To maintain the reliability of the amplifiers, the use of vacuum tubes should be avoided. Demodulators using selenium rectifiers in a balanced bridge arrangement are available commercially but the unbalance with zero input signal is generally intolerable for low-level servo applications. The relatively high threshold voltage of a selenium rectifier makes the demodulation of signals below several hundred millivolts difficult and makes good linearity difficult to obtain at low-voltage levels.

A demodulator circuit that does not suffer from the disadvantages of the selenium rectifier units but that avoids the use of vacuum tubes is shown in Fig. 1. It is a transistor demodulator that has been combined with a stable high-gain 2-stage magnetic amplifier to produce a unit that is very effective in a synchro-controlled position system.

OPERATION

THE DEMODULATOR CIRCUIT is one of a newly developed class of transistor circuits in which the transistors are used as switches.[1] An alternating reference voltage is applied between the base and collector of the *p-n-p* transistors. When the base is positive with respect to both the emitter and collector, the transistors will act as open switches with very low leakage. When the base is negative with respect to either, the transistors will act as closed switches with very-low-voltage drop.

The modes of operation are illustrated in Fig. 2. The transistor pair, when acting as a closed switch, will pass current in either direction if the reference source supplies sufficient base current. Since the transistors are being used as switches, rather than as amplifiers, their characteristics are not critical and the units do not have to be carefully matched. Furthermore, the transistors can have poor amplifying characteristics and still be successfully used. The property which is most important is the Zener voltage characteristics of the transitors. The maximum signal

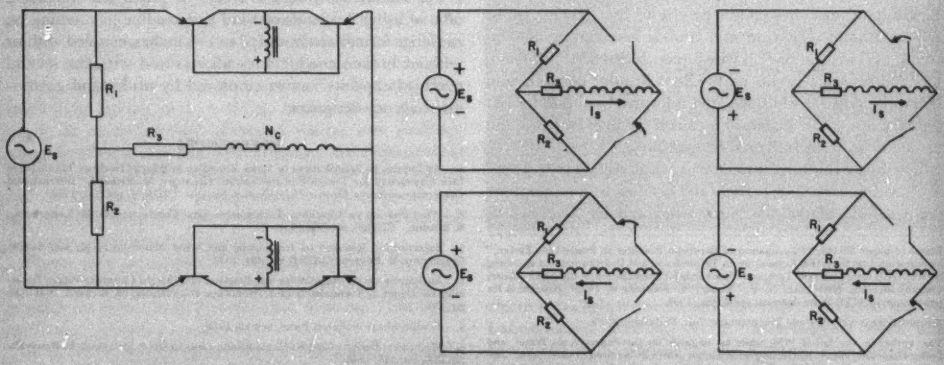

Fig. 1 (left). Transistor demodulator. Fig. 2 (right). Modes of operation of transistor demodulator

voltage E_g appears across the emitter-collector junction of one transistor during the time that one pair of transistors is acting as an open switch; thus the junction must be able to withstand the peak voltage which the signal source can supply. For many synchros this maximum voltage is 30 volts rms, and the transistors must then have a Zener voltage of 42 volts.

In the circuit of Fig. 1, two resistors R_1 and R_2 are shown; these are used to provide a split signal source. However, in some applications these can be replaced by a split secondary of an input transformer. The two resistors R_1 and R_2 do not have to be carefully matched because it can be seen from Fig. 2 that for either phase of the alternating voltage to be demodulated, the circuit operation is symmetrical, and the balance of the unit will not be affected by an unbalance in R_1 or R_2. The nominal value for this application is 10,000 ohms, because the recommended minimum load for a synchro control transformer is 10,000 ohms. It can be seen from Fig. 2 that for very low values of load resistance, the minimum resistance seen by the signal source is $R_1 = R_2$. For other applications, the resistors R_1 and R_2 may be chosen to be any value with the minimum value being set by either the loading of the signal source or the maximum permissible current of the transistors. Of course, the resistance of the load will have to be considered also because of the current division between the load and bridge resistances. R_3 in many applications is the resistance of the control windings, with no external resistance being necessary.

The reference voltage needed for switching the transistors is approximately 1 volt and is supplied from two separate secondary windings of a transformer T_1. The reference voltage should be as nearly as possible in phase with the voltage of the signal source because the transistors block only when the proper polarities exist between the various terminals. In the experimental unit discussed subsequently the reference voltages were obtained by adding two additional secondary windings to the supply transformer of the first stage of the 2-stage magnetic amplifier.

EXPERIMENTAL CHARACTERISTICS

To illustrate by practical application (Fig. 3), the demodulator has been combined with a 2-stage magnetic amplifier that has a high-volt-per-ampere-turn gain when direct current is supplied to the control windings. The control transformer will supply a phase-reversible 400-cycle voltage that will be a measure of the relative position of the shafts of the control transformer and synchro transmitter. The voltage gradient of the control transformer is 400 millivolts per degree with a maximum output voltage of 27 volts.

The d-c output current vs. applied voltage characteristic of the demodulator was measured at room temperature −65 C, and +75 C. The unit was kept at the extremes of temperature for 4 hours before the measurements were made. The curves are shown in Fig. 4. With R_3 equal to 2,000 ohms, the null point shift under temperature extremes is less than 1 microampere. The data plotted in Fig. 4 were taken with voltage applied from the control transformer. In this particular system, control transformer voltage is not exactly in phase with the reference voltage applied between the transistor terminals; thus the rectification efficiency of the demodulator is 78 per cent.

It will be noted that the characteristics remain linear even

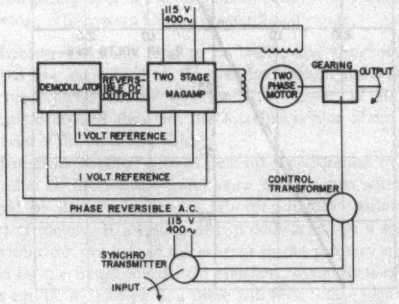

Fig. 3. Position servomechanism using transistor demodulator combined with 2-stage magnetic amplifier

at small voltages. This linearity exists for voltages at least as small as 20 millivolts which is the noise level of the synchro units. The influence of the magnetic amplifier on the demodulator, and conversely, was tested by measuring the output current of the demodulator, both with the amplifier control winding short-circuited and connected. The difference was no greater than that caused by the resistance of the control winding alone. The effective resistance of the demodulator which determines the time constant of the first-stage amplifier is

$$\frac{R_1R_2}{R_1+R_2}+R_3$$

if the internal resistance of the signal source is neglected. For most applications, the effective resistance can be maintained at approximately 10,000 ohms, and the first-stage amplifier can be made to have a response time no greater than 3 or 4 cycles of the supply frequency. The first stage, which is usually a d-c to d-c amplifier, can then be treated as an operational magnetic amplifier.[2] Series lead or lag networks can be used with the d-c to d-c amplifier, or feedback through frequency-sensitive networks around the amplifier can be used to provide system compensation.[3] Fig. 5 is a plot of the frequency–response characteristics of the system shown in Fig. 3. The amplifier response has been extended by negative integral feedback around the first stage and by a series compensating network between amplifier stages. The negative integral feedback network supplies a steady-state feedback to stabilize the amplifier against temperature, voltage, and frequency variations

Full text of paper 55-67, "Transistor Demodulator for High-Performance Magnetic Amplifiers in A-C Servo Applications," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Communication and Electronics*, March 1955, pp. 121–3.

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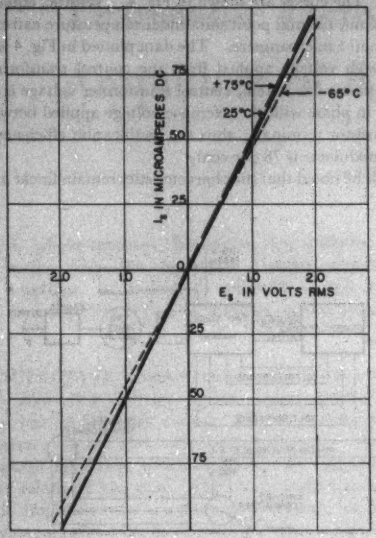

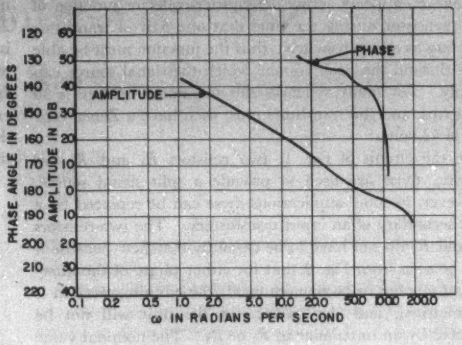

Fig. 4 (left). D-c output current vs. a-c signal-voltage characteristics of transistor demodulator. Fig. 5 (above). Frequency-response characteristics of position servomechanism

By using negative feedback in this manner it has been possible to reduce the drift level of a magnetic-amplifier position servomechanism with a transistor demodulator to a position error of 0.1 degree over an ambient temperature range of −65 C +71 C, and with 10-per-cent variations in supply voltage and frequency.

CONCLUSIONS

THE TRANSISTOR DEMODULATOR described is a stable detector and demodulator capable of operating at signal voltage levels at least as low as 20 millivolts and as high as 30 volts rms with low drift over the temperature range from −65 C +75 C. It is extremely well suited for operation in a synchro-controlled system because it can be readily combined with a stable full-wave magnetic amplifier.

The magnetic-amplifier–transistor-demodulator combination makes a stable high-gain amplifier that will amplify a-c signals and still enable the full amplification capabilities of the magnetic amplifier to be utilized. For synchro-controlled systems the sensitivity and drift stability are great enough that errors caused by inaccuracy in the magnetic-amplifier–transistor-demodulator combinations are not limiting factors in the over-all servo performance.

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Two Major Airlines Add Selective-Calling Radios

Two major U. S. airlines have purchased "private-line" auxiliary-communications devices which increase flight safety by freeing the pilot for his most important tasks. Pan American World Airways has ordered 47 Motorola dual air-borne "Quik-Call" units for "Selcal" on aircraft operating in their Latin American and Pacific Alaska Divisions. United Air Lines is buying 198 single units for fleet-wide installation, together with associated base station equipment.

Under the Motorola selective-calling method, an aircraft radio receiver remains silent until it is triggered by special tones transmitted by ground stations prior to the start of each message. The ground-station operator presses buttons on a control box to select the tones which will trigger any given receiver—in effect giving the ground operator a private line to that plane's pilot. The Motorola selective-calling equipment was developed jointly with Pan American's Pacific Alaska Division and has undergone extensive flight testing which shows that the selective-calling system reduces pilot fatigue appreciably by relieving pilots of the monitoring chore. With Motorola air-borne "Quik-Call," only messages intended for a particular pilot or pilots pass through the selective decoder and are heard by him or them.

Noncontacting Vibration Pickups

H. F. CLARKE

THIS digest discusses a group of methods for the measurement of vibration by devices which make no mechanical contact with the vibrating object. These devices sense the vibrations by their effect on an electric field between the pickup and the object shaken and give the magnitudes of the frequency, amplitude, and waveform of the vibratory displacements. In spite of the disadvantage of determining accelerations by measuring the frequency, amplitude, and waveform of the displacements, owing to the very large range of displacements required to hold constant acceleration through considerable frequency changes, these devices are highly useful. Effectively, they are a class of transducers for converting mechanical displacement to electric output which do not load the vibrating object.

Capacitive systems measure vibration by the variation of capacitance between the object shaken, which is grounded, and a plate or probe connected to the sensitive terminal of the circuit. The first transducer of this type was the capacitor microphone. The chief problems of using capacitive systems to pick up vibration arise from the loading of the sensing element by lead capacitance, and from obtaining linearity. The usual d-c excitation of the capacitor microphone through a large resistor, which for output signal purposes is in shunt with the transducer, is not suitable for any vibration measurement in which it is intended to use the transducer as a transfer system between static and dynamic displacements. For this purpose, a carrier system must be used. One common type of carrier system often suggested is to let the capacitance of the transducer control the frequency of an oscillator, but this method is still subject to the limitations already described.

Microwave systems detect vibration by the change in the reflection coefficient of a waveguide or coaxial line whose terminating end is open and placed close to the vibrating object. They depend on the fact that at very high frequencies, relatively small geometry changes can produce large reactance or susceptance changes, and the effect of these changes can be propagated down an electrically long transmission line without appreciable loss. There are two types which might be described:

1. In the first method, power is fed from an oscillator through an element whose purpose is to isolate the oscillator from variations in the load. From here the power is fed into a conventional hybrid junction of the type called the "Magic T." One arm of this T ends in an open piece of waveguide placed close to the vibrating surface. The opposite arm of the T is terminated by an arbitrarily variable impedance. The output arm of the T feeds into a crystal detector.

2. In the second method, an oscillator feeds power through an isolating element into a directional coupler set so as to pick up only reflected power. From here the power passes through a single-screw tuner, through a choke flange coupling, out to the vibrating object, is reflected, and re-enters the system, so that ultimately a portion of it passes out the pickup arm of the directional coupler into a crystal detector. This system has the greater linear range.

Microwave systems tend to be bulky, and their output level is low compared to that of the mutual inductance systems presently to be described. However, of all the systems described they are the least particular about the material of the vibrating object.

Mutual inductance systems pick up the vibration by the variation of the mutual inductance of two coils which is caused by the proximity of a vibrating highly conducting sheet of metal. If a system of two coils is fed by a source such that the product of the current in the primary multiplied by the frequency is held constant, dimensions of the coils can be so selected that there will be a linear region in the curve resulting from plotting the target distance against the output of the secondary of the two coils. Such systems have been developed by Yates, Davidson, and Greenough[1,2] of the National Bureau of Standards.

Recently, W. W. Woods of Boeing Airplane Company developed an improved mutual inductance system in which the variation of mutual inductance is used to control the frequency of an oscillator, thus making the device an FM system. The resulting signal is handled in a manner similar to the standard manner of detecting frequency-modulated signals, and is fed after detection to suitable measuring instruments. The transducer has high sensitivity, and although work is not yet complete, it is expected to prove quite stable.

The mutual inductance method is probably the most particular system about the nature of the object whose vibrations it senses; nevertheless, its convenient probe size and its high output make it among the most promising of the methods of sensing vibratory displacements.

A further difficulty of the mutual inductance pickup lies in the large ratio of required target size to length of the linear region in the input–output curve. On the whole, each system offers its advantages, and further evolution can be expected in the whole field. In the writer's opinion, the full exploration of either the microwave or capacitive systems remains yet to be done.

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Solid-Core High-Voltage Bushings

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A HIGH-VOLTAGE bushing which successfully sustains repeated application of 60-cycle and impulse test voltages may not be adequate for prolonged operation at rated line-to-ground voltage. Tests to evaluate bushings at voltages slightly in excess of operating have, therefore, been devised.

Three methods of measuring corona have been used to evaluate a line of resin-bonded solid-core bushings. These bushings have been in production and given satisfactory service since 1932. The tests include measurement of radio noise in microvolts using standard circuits, measurement of corona intensity in micromicrocoulombs using the resonant-circuit technique, and power-factor measurements as a function of voltage.

Power-factor, corona-intensity, and radio-noise measurements at various voltage levels and at temperatures ranging from 5 to 80 C were effected on solid-compound cores rated 69 kv.

The corona characteristics of the solid-compound core differ considerably from those of liquid-permeated structures. It has been shown[1] that for the latter, ionization characteristics vs. voltage can reveal incipient failure of the insulation.

Typical information of this nature which was obtained on capacitors shows that such structures possess a so-called break point in the corona-intensity curve. Continued operation at voltages above this point is damaging in a relatively short time.

Corona-intensity levels of the solid-core structure, in contrast with those for liquid-filled systems, vary gradually with increasing voltage. The shape of the corona vs. voltage curve is typical of the restricted ionization characteristic associated with voids in a solid structure. It represents the ionization level of the weakest link in the dielectric at any given voltage. This characteristic curve is quite reproducible in the normal product, indicating that no damage has occurred.

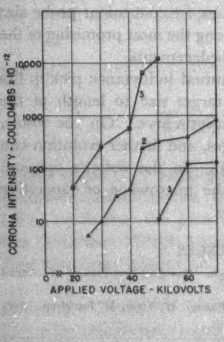
The data collected indicate a close similarity between radio-noise and corona-intensity measurements Because of these similarities, and due to the facility with which the radio-noise measurement may be effected, a conducted radio-noise test is now in use as a routine quality-control test for bushings using solid compound cores.

The relationship between power factor and voltage with the solid core is greatly influenced by the test temperature. The position, and even the existence, of a bend in the power factor vs. voltage curve are dependent upon temperature level.

Correlation between the power-factor bend and actual measurement of corona is difficult. Three sets of comparative data illustrated in Figs. 1 and 2 show this quite clearly. These data, while not normal for the standard product, do show (sample no. 1) that a power-factor bend may occur while corona is nonexistent and, conversely, that the power-factor bend may be negligible (sample no. 2) although ionization exists. Data also illustrate that correlation does exist between power-factor vs. voltage and corona measurements (sample no. 3) when corona is severe.

Conclusions drawn on all of the data taken on the solid compound cores are as follows:

1. The basic design evaluated is entirely satisfactory for bushings rated 69 kv and below. Such bushings will last indefinitely in service if properly evaluated initially.
2. The use of the power factor–voltage curve as a basis for determining incipient failure can result in rejection of bushings having negligible internal corona and in passing bushings having significant internal ionization.
3. Either the radio-noise or resonant-circuit method of corona detection is a dependable quality-control test on the design evaluated. The simplicity of the radio-noise test makes it more easily adaptable to production testing and field checking.
4. It is essential that comparative power-factor vs. voltage measurements be made at carefully controlled temperatures.



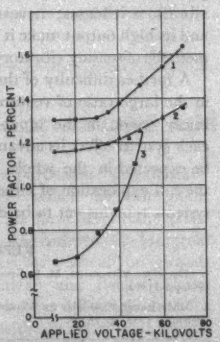


Fig. 1 (left). Effect of variations in core structure on corona vs. voltage characteristics. Fig. 2 (right). Effect of variations in core structure on power factor vs. voltage characteristics (data from same cores as Fig. 1)

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Radiation Counter for Beta Particles

D. T. WILLIAMS

This conduction-type counter uses a cadmium-sulfate crystal mounted in a hypodermic needle; a probe preamplifier of low noise was designed to be used with it. An analysis of the geometry of the problem has been derived to yield the counting rate in terms of the crystal size, concentration of radioactive atoms, their mean life, and the end-point energy of the beta particles.

A RADIATION COUNTER small enough to use in the body of a living animal or person has many useful applications. It might be used in radiation treatment of cancer, or in control of cancer surgery; it also could be used in tracer experiments on living subjects.

Three types of radiation counters are known, and all three types have been made in sizes small enough to fit into a hypodermic needle.[1] The research reported here concerns a crystal conduction type of counter designed to be sensitive to beta (β) particles. Similar counters have been briefly reported, notably by Zizzo and Platt.[2] This type of counter has an advantage over the Geiger-Muller type in that its sensitivity to β particles of small energy is not reduced by the need for a gastight window; its efficiency is likewise greater because its density is higher than that of the gas in a Geiger-Muller tube. As compared to a scintillation-type counter, the conduction counter has the advantage of not requiring a light-conducting tube inside the hypodermic needle. A great disadvantage is that counting crystals usable at room temperature are not generally available at the present time. However, a limited number of counting crystals was obtained for use in the project reported here.

DEFINITION OF THE PROBLEM

IT IS NOT EASY to make a small counter that will give an adequate counting-rate. This is true for a number of reasons quite beside the difficulty of building any small device; it is instructive to consider the problem in some detail.

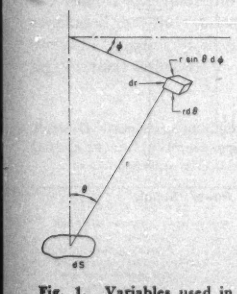

Fig. 1. Variables used in analysis

The first limitation of a small counter is the fact that the number of counts per minute recorded is proportional to its sensitive volume. A counter in a needle, being small at best, will require a larger flux of β particles for given desired counting rates in inverse ratio to its volume.

If the counter is designed for β particles, it can count such radiation from only a limited volume of the medium in which it is used. This fact results from the limited range of β particles in matter. It must, of course, be remembered that β particles do not all have the same energy initially. This means that, in order to have a given counting rate in any experiment, the concentration of radioactive material must be appropriately large if the β-particle energy is small; also, the actual distribution in energy of the particles must be kept in mind.

Finally, a very special difficulty is associated with any attempt to use such a weak β particle as that of Carbon 14, even though its use would otherwise have considerable attraction. This difficulty is the circumstance that the mean life of any radioactive atom is always greater as the energy of its emitted particle is less. A consequence of this fact is that the concentration of radioactive tracer must be in inverse ratio to its mean life for a given counting rate, again, other things being equal.

These considerations have been analyzed with some care, and will be presented in detail in the following paragraphs.

DISTRIBUTION OF β PARTICLES IN ENERGY

THE FACT was mentioned that β particles do not all have the same initial energy when they are emitted from a given type of atom. The energy distribution is expressed in the form of a probability $P_\epsilon d\epsilon$ that a given β particle will have an energy ϵ between $\epsilon + d\epsilon$. According to the Fermi theory

$$P_\epsilon d\epsilon = K\epsilon\sqrt{\epsilon^2-1}(\epsilon_0-\epsilon)^2 d\epsilon \qquad (1)$$

Here ϵ is the "total energy" of the electron expressed in units of $m_r c^2$, where m_r is the rest mass of an electron and c is the speed of light. The minimum possible value of ϵ is obviously equal to 1, at which energy the kinetic energy is 0. According to the theory of relativity, when ϵ is greater than 1, it may be written $\epsilon = mc^2$ where $m > m_r$. The maximum value of ϵ is ϵ_0, the so-called "end-point" energy of the radioactive transition.

It is clear that $P_\epsilon = 0$ at $\epsilon = 1$ and again at $\epsilon = \epsilon_0$; between these limits, P_ϵ is, of course, greater than 0. The constant K is a proportionality constant whose value is adjusted by the "normalization" condition, such that

$$1 = K\int_1^{\epsilon_0}\epsilon\sqrt{\epsilon^2-1}(\epsilon_0-\epsilon)^2 d\epsilon \qquad (2)$$

This means, in effect, that a β particle must have some value of energy between 1 and ϵ_0.

FORMAL THEORY OF COUNTER GEOMETRY

THE QUALITATIVE considerations mentioned in the fore-

Full text of District paper DP 55-306 presented before a session of the AIEE Committee on Electrical Techniques in Medicine and Biology at the AIEE Middle Eastern District Meeting, Columbus, Ohio, May 4-6, 1955.

D. T. Williams is with Battelle Memorial Institute, Columbus, Ohio.

Fig. 2. Cadmium-sulfide-crystal probe counters for the Chemical Corps Medical Laboratories

going have been formalized in a mathematical theory that will be briefly reviewed.

Suppose a surface dS of the counting crystal be immersed in a medium having a concentration n of β-emitting atoms with mean life T. An elemental volume $r^2 \sin\theta\, dr\, d\theta\, d\phi$ at a distance r from the surface (Fig. 1) will be the source of β particles which will enter dS and be detected as counts. The number of counts d^3N in time dt, due to those particles having total energy between ϵ and $\epsilon+d\epsilon$, is

$$d^3N=\left[\frac{n}{T}dt\right][K\epsilon\sqrt{\epsilon^2-1}(\epsilon_0-\epsilon)^2 d\epsilon]$$
$$\left[\frac{dS\cos\theta}{4\pi r^2}\right][r^2\sin\theta\, dr\, d\phi\, d\theta] \qquad (3)$$

In this expression, the first factor on the right is the number of β disintegrations per cubic centimeter of the medium in time dt; the second factor is the fraction of those disintegrations that will have total energy between ϵ and $\epsilon+d\epsilon$, as previously discussed. The third factor is the solid angle subtended by dS at the distance r from the elemental volume $r^2 \sin\theta\, dr\, d\theta\, d\phi$. The angles θ between r and the normal to the surface dS, and the azimuth ϕ, are shown in the figure.

Equation 3 is easily integrated with respect to r, θ, S, and ϕ. The result is

$$d^3N=\frac{n}{4T}dt\, K\epsilon\sqrt{\epsilon^2-1}(\epsilon_0-\epsilon)^2 d\epsilon\, Sr(\epsilon) \qquad (4)$$

where S is the total area of the counting crystals. The integration with respect to ϵ to yield the counting rate can be carried out only if the range r is specified as a function of energy ϵ. The usual form used to express $r(\epsilon)$ is

$$r=\alpha(\epsilon-1)^p \qquad (5a)$$

where p is a number that falls somewhere between 1 and 2, as ϵ varies from 1 to 2 or more.

The range as given in equation 5a is written with neglect of that range required within the crystal itself, in order that a count may be recorded. If it is assumed that a minimum energy ϵ_m is required of a β particle in order for a count to be made, the range r becomes

$$r=\alpha[(\epsilon-1)^p-(\epsilon_m-1)^p] \qquad (5b)$$

With this expression for range, equation 4 becomes

$$\frac{dN}{dt}=\frac{Sn\alpha K}{4T}\int_1^{\epsilon_0}\epsilon(\epsilon^2-1)^{1/2}(\epsilon_0-\epsilon)^2[(\epsilon-1)^p-(\epsilon_m-1)^p]d\epsilon \qquad (6)$$

In principle, this equation could be integrated for any desired value of p by numerical means. For p an integer, the integration can be carried out analytically; for such a case

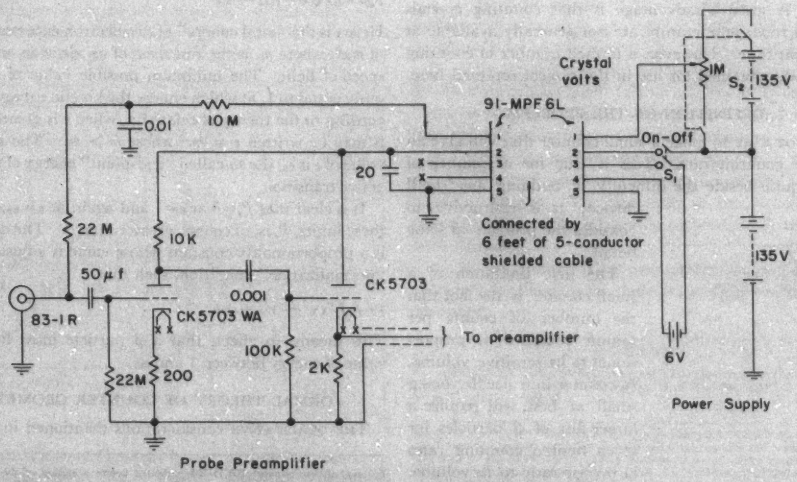

Fig. 3. Low-noise probe preamplifier unit

the integral of equation 6 reduces to a series of terms involving factors of the form

$$F(\epsilon) = \int_{\epsilon}^{\infty} \epsilon^{n}(\epsilon^2-1)^{1/2}d\epsilon \qquad (7)$$

These factors can be integrated by parts to yield results which are summarized, for different values of n, in Table I.

Table I. Values of the Indefinite Integral $\int \epsilon^n(\epsilon^2-1)^{1/2}d\epsilon$ for Different Values of n

$n=0$:	$1/2[\epsilon(\epsilon^2-1)^{1/2}-\log(\epsilon+\sqrt{\epsilon^2-1})]$
$n=1$:	$1/3(\epsilon^2-1)^{3/2}$
$n=2$:	$(\epsilon^2-1)^{1/2}\left(\frac{\epsilon^2}{4}-\frac{\epsilon}{8}\right)-1/8\log(\epsilon+\sqrt{\epsilon^2-1})$
$n=3$:	$(\epsilon^2-1)^{3/2}\left(\frac{\epsilon^3}{5}-\frac{2}{15}\right)$
$n=4$:	$(\epsilon^2-1)^{1/2}\left\{\frac{\epsilon^5}{6}-\frac{\epsilon^3}{24}-\frac{\epsilon}{16}-\frac{1}{16}\log(\epsilon+\sqrt{\epsilon^2-1})\right\}$
$n=5$:	$(\epsilon^2-1)^{3/2}\left(\frac{\epsilon^4}{7}+4/35\epsilon^2+8/105\right)$

The value of the constant K can be found directly by use of the table, since equation 2 expresses the value of K in terms of the form of equation 7. Since K depends on the end-point energy ϵ_0, there will be a different value of K for each β emitter to which this analysis is applied.

SUMMARY OF THEORETICAL PREDICTIONS

THE THEORY just derived has been used to compute the concentration in water n of (*a*) radioactive Carbon 14, and (*b*) Phosphorus 32, required to produce a counting rate dN/dt of 25 counts per minute. The results of these calculations are presented in Table II. It is shown there that the concentration in atoms per cubic centimeter required to produce a counting rate of 25 counts per minute in a detector in a hypodermic needle is 2.794×10^{15} and 6.57×10^{8} for Carbon 14 and Phosphorus 32, respectively. These figures represent somewhat optimistic estimates in that the range of particles within the crystal required to produce a pulse has been considered negligible, and no allowance has been made for the presence of a window over the counting element. The reliability of the estimates would be expected to be greater for the case of phosphorus; the Phosphorus 32 β-ray energies are great enough so that the factors neglected in the theory are more likely to be negligible in fact than is anticipated to be true for Carbon 14. It was concluded that the fabrication of a counter that would be useful in experiments where Carbon 14 is the tracer would be extremely difficult.

Table II. Summary of Computation of Concentration n of (*a*) Carbon 14, and (*b*) Phosphorus 32 Required to Produce a Counting Rate dN/dt of 25 Counts per Minute

(δ=0.0179 cm^3, =1)	Carbon 14	Phosphorus 32
1. End-point energy ϵ_0, units of mc^2	1.303	4.33
2. Mean life T, minutes	2.938×10^{9}	3.031×10^{4}
3. Normalization factor K	268	0.0254
4. Exponent in range equation p	2	1
5. Equation for range, cm	$r=0.414(\epsilon-1)^2$	$=0.41(0.676\epsilon-1)$
6. Integral in equation 6	5.2948×10^{-9}	36.650
7. Concentration n, atoms/cm^3	2.794×10^{15}	6.57×10^{8}

FABRICATION OF THE COUNTER

CRYSTALS that are capable of detecting β particles have not been found generally. In the work reported here, there were three sources of cadmium-sulfide (CdS) crystal available to Battelle, but the only β-counting crystals found were among a supply kindly provided by Dr. Rudolph Frerichs of Northwestern University.

After a counting crystal of appropriate size and shape was found, it was mounted in the tip of a hypodermic needle in the following way: A wire insulated by a small glass tube is flattened on the end and slipped into the needle so that the end is just inside the sharp end of the needle. Wire and glass insulation are cemented in place with Formvar, and

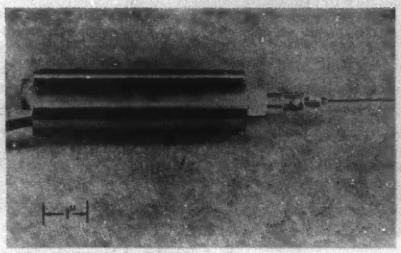

Fig. 4. Probe preamplifier with counter needle

the space beneath the flattened end of the wire filled with the same cement. The crystal is then placed on the flattened electrode with good electric conduction insured by use of a drop of aquadag. After the aquadag dries, the crystal is secured in place by use of Ethocel (ethyl cellulose in Vinsol). Successive layers of Ethocel are used to fill all the space between crystal and needle, care being taken to leave the crystal bare on top. A layer of silver about 200 angstroms thick is then deposited over the crystal, Ethocel, and bare end of the needle to form the other counter electrode.

It was at first presumed that a crystal mounted in this way would count without further modification. However, it was found that immersion in water caused excessive noise in the counter circuit. When Ceresin wax is used to cover the silver outer electrode, the noise is no longer observed, and the counter functions according to design.

Three counting crystals were mounted in this fashion. Fig. 2 shows them set in protective glass tubes. Two of the needles are size 17; one is size 22.

THE PREAMPLIFIER

IT IS a fundamental characteristic of all β-particle counters that they must count different sizes of pulse. How weak a pulse may be, and still be counted, is fixed arbitrarily by use of a discriminator in the amplifying circuitry. The best setting of the discriminator is that for which most of the counts recorded are due to β particles and few, or none, to noise in the circuit. It follows from this that the first ampli-

fying stage of the counter should be especially free of noise. In addition, the first stage should be small, and arranged to be very close to the crystal so that the input capacitance can be as small as possible. Finally, the first amplifier tube should be a triode with moderate gain.

The probe preamplifier was made to meet these conditions. Figs. 3 and 4 show the probe preamplifier circuit and the instrument with and without its brass case. The components are small so that the case is $1^3/_4$ inches in diameter by $5^1/_4$ inches long. The power supply is a battery in a separate unit. The output of the "probe preamplifier" was connected to a second preamplifying circuit which was connected in turn to an amplifier with counter. The performance of the needle was tested by use of a solution containing Phosphorus 32; its operation was noise-free and satisfactory in every way.

TESTS ON THE MOUNTED CRYSTALS

A TEST was made of the "counting efficiency," or the number of electron volts dissipated in the crystal for each carrier created. A source of radiation was used of end-point energy, sufficient so that the highest pulses observed were caused by particles that penetrated completely through the crystal. The voltage thus lost by the β particle was computed by the range equation from the crystal thickness. The number of carriers N_e produced in the crystal was then computed; the pulse height observed was duplicated by a pulse generator of known pulse voltage V. The total number N_e of carriers could be computed from the pulse height V and the measured capacitance C of the counter and its grid circuit by the relation

$$N_e = \frac{Q}{e} = \frac{1}{e} VC$$

Here Q is the total charge generated in the counter pulse, and e is the charge on an electron. The energy lost by the particle per carrier created was found to be 7.8 and 9.5 volts for two different crystals. This is in agreement with the figures for CdS crystals reported by Kallmann.[3]

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2. Detection of X-Ray Quanta by CdS Crystal Counter, S. Zisso, J. R. Platt. *Physical Review*, New York, N. Y., September 1949, p. 704.

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5-Cycle Distribution Power Circuit Breaker

The first 5-cycle power circuit breaker for distribution applications was announced by the General Electric Company's High Voltage Switchgear Department, Philadelphia, Pa. The new circuit breaker, which is rated to interrupt distribution loads in 5 cycles at 14.4 kv, is the fastest breaker of this type ever made available. The new breaker, shown here as tests were completed, will provide distribution engineers with the opportunity to increase transformer sizes to meet load growth without changing to heavier wire sizes.

The higher speed will minimize the chance of line burndown and also offers close co-ordination of fuses. On typical systems using 1/0 wire, the new breaker would permit transformer capacities to be increased 68 per cent over burn-down values considered safe for the standard 8-cycle breakers now in use. Faster interruption will also enable better fuse protection of distribution equipment because smaller ratings of co-ordinated fuses may be utilized.

Significant reductions in size have also been achieved. The new stronger cylindrical-tank circuit breaker requires 26 per cent less station space than did the previous square-tank breakers. Six bayonet-type interrupters have been incorporated into the design of the single-tank construction.

The 5-cycle breaker supersedes the General Electric Company's previous 8-cycle unit, and is being introduced at no increase in price. The new breaker has been subjected to extension full-scale power and capacitance switching tests at the company's development laboratory in Philadelphia, Pa. Although rated at 5 cycles, oscillograms repeatedly show operating times well within that rating.

A stored-energy torsion spring and a low-impact cam-drive mechanism have been teamed to achieve smooth closing in the new breaker. The mechanism can provide instantaneous initial reclosing even if closing power supply is not available. Powered by a 400-watt universal motor, the spring-charged mechanism eliminates the need for heavy closing power-supply sources normally required with present distribution breakers.

Circuit Breakers for Switching 230-Kv Lines

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MEMBER AIEE

D. J. MARSDEN
MEMBER AIEE

EXCESSIVE TRANSIENT VOLTAGES are the principal concern in switching long 230-kv lines. Such voltages are usually the result of commutation of line capacitance with respect to supply voltage by restriking of line circuit breakers. Experience has shown that restrikes will generally produce higher voltages on long lines than on relatively short lines. This is because the breakers will usually interrupt long-line restrike current at the first current zero, leaving the line charged at high potential, which in turn is apt to result in even higher transient voltage should further restrikes occur. Thus consideration must be given to breaker design safely to permit line switching.

Some of the factors that must be considered before modifying a standard circuit-breaker design for long-line switching duty are: cost, reliability, freedom from excessive maintenance, and the increasing performance requirements of high-voltage circuit breakers as applied on modern utility systems. In general, the design chosen must be at least competitive in all respects from the user's standpoint.

A 230-kv circuit breaker was modified safely to permit long-line switching by the addition of 2,400-ohm interrupter shunting resistors for the following reasons: (1) they could be accommodated to the existing breaker design without serious modification; (2) the resistors can be applied so that equal voltage division between the four interrupting breaks per pole can be maintained under nearly all conditions, mainly because of rather high distributed capacitance designed as part of the resistors; (3) this resistor type can improve circuit-breaker performance during fault interruption; (4) relatively low resistance more effectively discharges the line following interruption, thus tending to reduce probability of restrikes; (5) these resistors can be applied so that they carry current for less than $1^1/_2$ cycles during an opening operation and less than 1/4 cycle during a closing operation, and arranged so the resistor current can be interrupted in interrupter chambers rather than in open oil; and (6) the resistors as applied do not impair the high-voltage circuit-breaker performance in any way.

Digest of paper 55-223, "Design Problems and Field Tests Concerning Circuit Breakers for Switching Long 230-Kv Lines, recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

D. M. Umphrey and D. J. Marsden were formerly with Federal-Pacific Electric Switchgear Division, San Francisco, Calif.

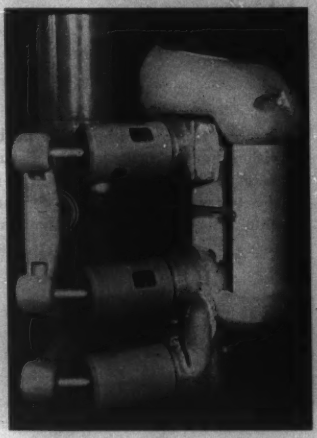


Fig. 1. View showing resistor mounted on interrupter, and center-tap connection between resistor and upper interrupting chamber

The resistors are installed as two separate units per circuit-breaker pole with each unit mounted on a bushing-supported interrupter and connected between the upper and lower stationary contact. Equal division of voltage between the upper and middle contacts is obtained by a probe contact connected to the center point of the resistor. Fig. 1 shows this construction. Increased distributed capacitance is employed to improve strength for withstanding steep wavefront high-voltage lightning or switching surges. Dangerous gassing of oil around resistors during interruption of severe faults is prevented by adequate thermal capacity.

In order to check operation of the breaker following resistor application, a series of line-dropping tests were made on 78.7- and 241.6-mile 230-kv lines. Table I indicates a summary of the average data for these tests which includes 53 line-dropping operations at sending-end voltages up to 250 kv. The resistor-equipped-breaker performance throughout the described series of tests was highly satisfactory. Capacitive current interruption was prompt and without restrikes. Residual resistor current interruption time was very short. System voltage was held to low and entirely safe values. The subject resistors have demonstrated excellent performance in withstanding severe impulse tests, in successfully switching long high-voltage lines with operating voltages beyond the upper limit of the breaker rating, and in withstanding the stress of severe fault-interrupting duty.

Table I. Summary of Average Data for Test Series A, B, C, and D

Miles of Line	Bus Kv, ϕ to ϕ	Line Amperes	Average Charging-Current Interrupting Time Cycles*			Average Resistor-Current Interval Cycles†			Average Per-Cent Crest-Voltage Left on Line		
			ϕA	ϕB	ϕC	ϕA	ϕB	ϕC	ϕA	ϕB	ϕC
78.7	246	61	2.3	2.3	2.1	1.5	1.4	1.7	54	54	53
241.6	246	204	2.7	2.6	2.6	0.9	0.8	0.8	11	9	13

* Time from energization of trip coil to interruption of charging current, 60 cycles per second.
† Time from interruption of charging current to interruption of resistor current, 60 cycles per second.

Basic Problems in Film Pickup for TV Broadcasting

E. M. GORE
ASSOCIATE MEMBER AIEE

Some of the most important problems of television film reproduction are discussed, emphasizing these problems from the standpoint of the television system. A commercially available color-film camera system utilizing three Vidicon pickup tubes is described.

FILM PROGRAMS now constitute a very large percentage of television air time. One network alone uses film at the rate of about 9,000,000 feet per month. Many of the major programs are recorded, for reasons of convenience, timing, or historical record. Some of the smaller stations have begun their operations using nothing but recorded material for all programs.

A minute portion of this enormous quantity of film was used for the generation of color television programs. Color programming is now steadily increasing and the volume of film used for color programs may equal the amount used for monochrome in a few years.

The use of film for television involves a very long chain of processes between the original scene and the reproduced image. Fig. 1 is a block diagram which indicates the chain of processes involved. The shortcomings of all of these processes can accumulate and satisfactory reproduction requires the solution of many technical problems. Evidence that the solutions are not unique is apparent from the different film camera equipments now being marketed. It is the aim of this article to discuss some of the most important problems of television film reproduction, especially from the standpoint of the television system. A commercial color-film camera system using three Vidicon pickup tubes is described.

FILM CHARACTERISTICS

FILM USED FOR TELEVISION is produced either by photographing the original scene or by recording television pictures. Positive prints are generally employed for monochrome use except that the original negative "Kinerecording" is frequently used for delayed broadcasts.

Color film requires much more care in photography and processing because of the interaction between the three dye images on the same film. Technical developments have indicated that the need for color television recordings can be met in the near future.[1]

The characteristics of film which are the most troublesome in television reproduction because of wide variation are the transfer characteristic shape, the density range, and the color quality. Noise (graininess) and lack of sharpness are frequently very objectionable in 16-mm prints.

Improvement of television film programs thus requires the co-operation of film manufacturers, photographers, and processors in addition to the effort expended on the pickup and reproducing devices.

FILM CAMERA TYPES AND TELEVISION PROJECTORS

FILM CAMERAS may be classified into two major types:

1. Flying-light-spot cameras focus a moving scanning spot, generated by a kinescope, onto the film frame. The transmitted light is proportional to the transmission of the film frame at that point and it is collected by a multiplier photocell to produce an electric video signal.

2. Storage-type camera tubes accumulate a charge image of the focused optical image during the interval of light exposure, between scans by an electron beam. Storage-type tubes include the iconoscope the image orthicon, and the Vidicon.

Systems which are now being used in the United States for film pickup are the flying-spot scanner, the Vidicon, and, of diminishing importance, the iconoscope and the image orthicon.

Both 16- and 35-mm films are shown at an average rate of 24 frames per second. United States television operates at a rate of 30 frames or 60 fields per second. Thus a 1-to-1 correspondence between film frames and television frames does not exist. The methods for conversion fall into two categories—intermittent projectors and continuous motion projectors.[2]

Intermittent projectors utilize a shutter (or pulsed-arc lamp) to interrupt the light during pulldown or change of frames. These projectors may be subdivided into three types:

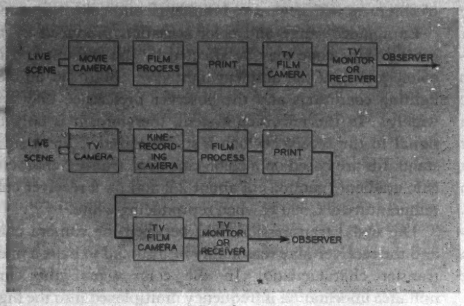
1. Projectors having uniform intervals between pulldowns allow 60 uniformly spaced exposures per second with short exposure time and moderately short pulldown time.

2. Projectors having nonuniform intervals between pulldowns—commonly called *3-2* mechanisms—expose alter-

Full text of paper 55-457, "Basic Problems in Film Pickup for TV Broadcasting," recommended by the AIEE Committee on Television and Aural Broadcasting Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955.

E. M. Gore is with the Radio Corporation of America, Camden, N. J.

The author expresses appreciation for information and constructive criticism from his associates in the broadcast television equipment group of the Radio Corporation of America, Victor Division. Those most closely concerned were H. N. Kozanowski, S. L. Bendell, T. J. Shipferling, and N. L. Hobson.



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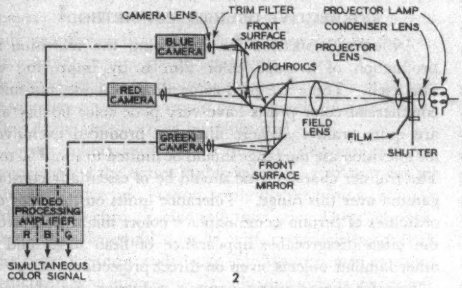

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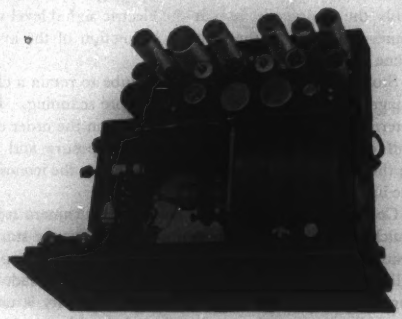

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Fig. 1. Processes involved in the television reproduction of film. Fig. 2. Basic 3-V color-film camera. Fig. 3. A Vidicon camera assembly for one channel. The base of the Vidicon may be seen extending from the rear of the magnetic deflection and focus assembly

nate film frames three times and expose the remaining frames twice. Pulldown times are of the same order as those for theater projectors.

3. Fast-pulldown projectors utilize the *3-2* mechanism and pull down the film within the interval of television vertical blanking.[5]

Continuous-motion projectors transport the film at uniform velocity. These may be also classified into three types:

1. Stationary-image projectors utilize moving lenses, prisms, or mirrors to maintain the projected image in a fixed position. The images of succeeding frames lap dissolve into each other.[1,4,5]

2. Single-line-scanning projectors use flying-spot scanning and depend on the film motion to give the vertical scan. These require special film operating at 60 frames per second.

3. Jump raster projectors utilize flying-spot rasters in two or more different positions for successive television fields. This is accomplished by a step centering waveform applied to the deflection coils of the flying-spot tube.[6]

With some combinations of projectors and cameras, precise synchronism between film transport and television scan rates is not required. This results in simplification and flexibility since the generation of motor-drive power at the television field frequency requires additional costly equipment.

For use with storage-type tubes, *3-2* type of projectors with moderate exposure are considered to be more reliable than fast-pulldown or continuous-motion projectors. This type of projector is now being marketed in several commercial versions. Flying-spot systems using stationary-image projectors are now being marketed.

QUALITY CHARACTERISTICS OF FILM CAMERAS

Resolution may be expressed as equivalent line number or video bandwidth.[7] Since the receiver video passband is limited to about 4 mc per second, any of the cameras mentioned can provide adequate response.

Camera light requirements are determined by the minimum highlight brightness which will yield an acceptable signal-to-noise ratio. For the Vidicon, however, the minimum highlight brightness is determined by the "lag" or long-time memory of the tube, which tendency decreases as the illumination is increased. In cameras where equalizers are employed to compensate for aperture responses, the noise level is correspondingly increased.[8]

Transfer characteristic shape is linear for image orthicon and flying-spot pickup devices so that some form of electrical "gamma" correction is required to compensate for

the nonlinear characteristic of the receiver kinescope. The iconoscope has variable gamma less than unity while the Vidicon has an essentially constant value of 0.65 for gamma. The useful brightness range of a camera is determined by the number of brightness steps of fixed ratio which can be identified in the electric output signal. The maximum brightness input is usually limited by a saturation effect (as in the knee of the image orthicon) or by poor resolution due to the high beam current or by the light source and optical system. The lowest brightness step discernible is usually determined by the electric noise level. An undesirable behavior of some storage-type tubes, notably the iconoscope, is that the electric signal level which represents black in the scene is a function of the average scene brightness.

Storage is the ability of a camera tube to retain a charge image after exposure to light and before scanning. Using intermittent-type projectors, an interval on the order of one half of a field may elapse between exposure and scan. In the order of increasing storage ability are the iconoscope, the image orthicon, and the Vidicon.

Color response of the three storage-type camera tubes is panchromatic, although it is not identical to the standard visual response. By the use of suitable phosphors, photocells, and filters, the flying-spot camera can be made panchromatic, although the red-channel sensitivity is usually much lower than the sensitivities of the blue and green channels.

OTHER ELEMENTS OF THE FILM REPRODUCING SYSTEM

THE OBSERVER'S IMPRESSION is the ultimate test of a television system's performance. The requirements of a television reproducer are based on the "normal" response of observers with regard to luminance and color response.[9]

Luminance range and color sensation produced by the receiver kinescope may be affected by the amount and the color quality of the ambient light.[7,10,11] Both the ambient lighting conditions and the observer preference may vary widely. In the television system, therefore, it is only the signal to the receiver which is standardized. These signal standards are based on a color-kinescope transfer-characteristic gradient (gamma) of about 2.2 and on a receiver color temperature of 6,500 K when reproducing white.[11]

The signal transmission links between the camera chain and the receiver may reasonably be assumed to have a linear transfer characteristic. In the color signal the chrominance information is frequency multiplexed into the high-frequency portion of the video band occupied by the luminance information.

CORRECTIVE DEVICES AND METHODS

AN OBVIOUS METHOD for improving the television reproduction of average color film is by improving the film itself. There are good color films available, but many commercial color prints have very poor color fidelity and are quite grainy. Where films are produced exclusively for television use the range should be limited to about 50 to 1. The transfer characteristic should be of essentially constant gamma over this range. Tolerance limits on the color coordinates of certain commonplace colors might help avoid the often disagreeable appearance of flesh tones and of other familiar objects, even on direct projection.

Transfer-characteristic gamma reduction by electrical methods increases the useful brightness input range for the

Fig. 4. Projection-room equipment for the 3-V camera. Two 16-mm television projectors are visible with an optical multiplexer which reflects the light into the camera in the foreground. The camera base houses the deflection circuits and the local controls. Fig. 5. Control position for the 3-V color-film camera. The front panel of the video-processing amplifier is below the color monitor. The remote control panel for the camera is on the desk but obscured, and a monochrome master monitor with oscilloscope is on the left of the processing amplifier

camera, provided that the camera noise level is sufficiently low. This method is particularly adapted to Vidicon cameras because of the excellent signal-to-noise ratio which Vidicon pickup tubes can provide. Electric operations analogous to photographic masking techniques can be performed.[7,12,13]

The theoretical sensitivity curves for cameras contain negative lobes which cannot be realized optically. Further errors are introduced by the absence of negative lobes in the film-taking sensitivities as well as by the dye crosstalk in the projected film. Partial correction can be achieved by the use of electric masking or linear combinations of the three signals.[14] The optimum matrix is, unfortunately, not the same for all films.

An operation roughly equivalent to masking can be accomplished by modifying the shapes of the camera-taking sensitivity curves slightly with optical filters. Since the scene has already been analyzed into primary color components by the film-taking sensitivities, no great error should result from the analysis of the light transmitted by the film with narrow-camera-taking sensitivity curves. The available signal with fixed illumination would be reduced and the signal-to-noise ratio would be decreased, but the degree of film dye crosstalk would be minimized.

Camera taking-sensitivities can be so designed that one channel covers the entire visible spectrum and contains all of the luminance information, while the remaining channels contain only chrominance information. These chrominance channels would operate with restricted bandwidth as required for the encoded signal. Monochrome receivers would utilize the information of only the luminance channel.

Aperture equalization permits compensation for some of the degradation of sharpness in the optical processes. The permissible degree of equalization is usually limited by the acceptable noise level so that it is important to minimize the degradations in each process.

VIDICON COLOR-FILM CAMERA SYSTEM

THE MONOCHROME VIDICON FILM CAMERA has replaced the iconoscope film camera in many installations during the past 3 years. Field experience has proved its ability to produce excellent pictures from good film and it is outstanding from the standpoint of reliability and low-cost operation. The factors contributing to the good results are[8,15]

1. Excellent signal-to-noise ratio, permitting a large amount of aperture equalization.
2. A 600-line limiting resolution. Approximately 40-per-cent response at 350 lines without equalization.
3. Stable black level with neglible dark signal.
4. Low gamma inherent, accommodating a wide range of film.
5. Simplicity and ease of adjustment.
6. Excellent storage characteristic permitting non-synchronous use with intermittent-type projectors.
7. Long life. Vidicons are warranted for 12 months or 500 operating hours, but field data show evidence of much longer life.

These advantages were, for the most part, retained when three monochrome Vidicon cameras were combined to form the 3-V color-film camera.[16] A block diagram of this film pickup system is shown in Fig. 2. The light from the projector passes through a relay-lens system and color-separation filters where it is divided into three primary color components each of which is focused on one of the Vidicon camera tubes. The video channels are independent so that the outputs are three simultaneous signals.

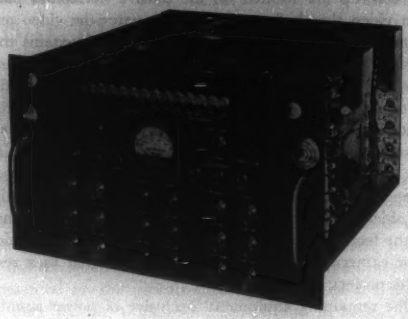

Fig. 6. Video-processing amplifier with four plug-in chassis. The mechanical design facilitates servicing

Because of the color-separation filters the illumination required for the color-film camera is nearly 20 times that required for the monochrome camera. Intermittent projectors having the *3-2* mechanism are used to obtain exposure cycles of about 50 per cent. By using a fast lens system, adequate illumination is obtained for even the most dense color film. An optical multiplexer was designed to permit the use of a slide projector or one of two film projectors. The film projectors use 1-kw incandescent projection lamps with infrared filters so that still frames can be projected without damage to the film.

The output voltage of each of the three cameras, at any instant, must correspond to the transmission through a single-picture element of the film frame. This registration requirement was fulfilled by the use of precision deflection and focus components, sturdy mechanical construction, and stabilized deflection circuits. Fig. 3 shows the new camera assembly. Center resolution of 600 lines and corner resolution of 400 lines can be obtained on a superposition of the three signals.

Fig. 4 shows the equipment layout at the camera position. All operating controls are available at the remote-control desk. For convenience in setup, however, these control functions are transferred to controls at the camera position by means of a switch. Vernier adjustments are provided on the registration controls.

Compensated video amplifiers on top of each camera feed coaxial lines to the remote-control position. An additional output from each amplifier passes through a selector switch to a projection room monochrome monitor.

The control position is shown in Fig. 5. Camera operat-

ing controls are located on the passive horizontal panel. The video signals from the camera enter the video processing amplifier shown in Fig. 6. This unit contains three parallel video channels which perform the operations of blanking modulation, gamma modification and shading (optional), and video power amplification. Functions which are performed in common to all channels are synchronizing pulse regeneration, monitor switching, and signal level calibration. This processing amplifier was developed as part of a project for color camera simplification. Considerable improvement in the state of the art is evidenced by the fact that the number of tubes in the image orthicon color camera chain was approximately halved as a result of this project.

The remaining equipment, exclusive of power supplies, required to produce a National Television Systems Committee encoded signal consists of the colorplexer, its auxiliaries, and a calibration pulse generator. Aperture equalization is provided in the luminance channel. The complete camera and encoding equipment uses five power supplies providing approximately 2 amperes at 280 volts direct current regulated.

This 3-V color-film camera has yielded very satisfactory film reproduction when used with good color film. Comparison of the resultant picture with a direct-projected picture shows remarkable fidelity. At present there are over 35 field installations in operation. The first installation, at the National Broadcasting Company in New York, has been in operation for more than a year.

CONCLUSIONS

A SUBSTANTIAL IMPROVEMENT in the television reproduction of color film can be achieved through better control of film, its exposure, and processing then is now evident in the average commercial color film. Receiver reproducing capabilities are limited as to contrast range; consequently the film range should also be restricted.

Signal-to-noise ratio is a most important measurable quantity, applying both to the film and to the television system. This ratio is basic to the determination of camera light requirements and contrast range, and may limit the corrections of gamma and detail rendition.

Certain electric operations can be used to modify television pictures in a manner similar to the photographic masking of films. Improvement of the reproduction of some films can be obtained by linear matrixing. Narrow television-camera-taking sensitivities can reduce dye cross-talk, but at the expense of signal-to-noise ratio.

The combination of the 3-V color-film camera and intermittent projectors is capable of giving remarkable color-film reproduction fidelity. The low noise level of the Vidicons permits operations such as aperture equalization and transfer characteristic modification while maintaining a good signal-to-noise ratio.

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World's Fastest Operatorless Elevators

An elevator hoisting machine, which weighs approximately 13 tons, is here shown being raised 40 stories to the top of the new Prudential Insurance Company Building located in Chicago, Ill. The huge motor is 1 of 10 such motors being lifted into place on top of the building to power high-rise "Autotronic" elevators. These elevators, which do not require attendants, are now being installed by the Otis Elevator Company. These cars will set a new world's speed record of 1,400 feet per minute for operatorless elevators. The building will be equipped with a a total of 30 elevators—27 passenger cars and 3 service elevators.

A Test Board for Watt-Hour Meter Standards

F. J. LEVITSKY
ASSOCIATE MEMBER AIEE

THE Central Laboratory of the New England Power Service Company maintains the watt-hour standards for the New England Electric System. Up to recently, calibration techniques were not satisfactory since not only field watt-hour meter standards but reference watt-hour meter standards showed errors, minor in so far as commercial yardsticks were concerned, but annoying from the laboratory point of view. To minimize these errors, test procedures and equipment were reviewed. The aim was to stabilize all conditions which might influence the reference standards, to eliminate in so far as possible the errors due to the human element, and thus reduce inaccuracies.

Using the best ideas which could be found among manufacturers and utilities, a new test board was designed and constructed. This board employs selected watt-hour meter standards operating under as near to ideal conditions as possible, and not only provides a simple and accurate means for the test of standards brought in from the field, but also permits immediate calibration of reference standards.

By employing three reference watt-hour meter standards, a quick intercomparison of these standards can be made. Friction was lessened by the removal of registers.

With the elimination of the registers, a major problem was the calibration of the reference standards. It was possible to use the photoelectric pickups installed in the standards to obtain a count of full revolutions only. A method previously developed uses this count of full revolutions in conjunction with a chronograph, giving precise time measurement, to compute watt-hours with time as the variable.

In spite of the accuracy of the chronograph it was believed that a definite time interval could be fixed more precisely than an indeterminate time interval could be measured, and did not introduce a human error in such time measurement. Thus it was decided, for calibration of the reference standards, to retain the 1-minute interval and to measure both partial and whole revolutions of the disks by employing an additional photoelectric pickup in each standard and an electronic counter.

To actuate the photoelectric pickup, 200 evenly spaced teeth approximately 1/16 inch deep were cut in the edge of the disks in each reference standard. Since the aperture between adjacent teeth would not transmit sufficient light to actuate the phototube, a metal plate, in which a 1/2-inch by 1/16-inch lattice had been cut, was mounted over a segment of the meter disk. The lattice openings match the slits in the disk to form a shutter. The photoelectric system has the light source above the shutter and the phototube below. As the disk rotates the light intensity on the phototube varies from a small value when the teeth in the disk are directly under the slots in the plate to a maximum value when the slots in the disk are in line with the slots in the plate, thereby giving 200 output pulses per revolution. The magnitudes of these pulses are still too small to be used directly, so a 2-stage amplifier is mounted on the pickup chassis. The amplified pulses are then fed to a high-speed electronic counter. This counter consists of a wave shaper, amplifier, and four decade counting units which give a direct reading of the number of pulses. The rated maximum input of the decade counting units is 40,000 pulses per second, while the maximum input rate in this circuit is 55 pulses per second.

To calibrate the reference standards, which run continuously, the power is held constant and the clock relay contacts operate the start and stop circuit of the decade counter. A total reading on this counter will give, when divided by 200, whole revolutions and partial revolutions of the reference standards to the nearest 0.005 revolution.

The accuracy of the decade-counting units is absolute ±1 count. Errors in starting and stopping have been minimized by the use of a high-speed start-stop relay.

Current and voltage for the field standards are obtained with uniload equipment. Through the use of precision transformers, the reference standards operate with constant magnitude voltage and current. From test results of the precision transformers made at the National Bureau of Standards, calculation of combined transformer errors to be expected at the commonly used calibration points shows a maximum of 0.03 per cent at unity power factor and 0.04 per cent at 50 per cent lagging power factor. These errors are considered insignificant and no transformer corrections are applied in routine calibrations.

As outlined above, absolute calibration of the reference standards is accomplished by holding the wattage constant and measuring revolutions and partial revolutions for a fixed time interval. No single test result on the reference standards is used, but the average of a number of tests.

The stability of the reference standards is considered excellent. Calibration data posted to the nearest 0.05 per cent show no change in the average calibration during the first 3 months of use.

A high degree of consistency among reference watt-hour meter standards has been achieved. Calibrations of these standards indicate a stability considerably better than had been shown by previous experience. In many ways the equipment is similar to that used by other laboratories; but by this technique using two photoelectric systems, it is possible to calibrate any one reference standard by laboratory indicating instruments, to intercompare any two of the three reference standards, to cross-check accuracy of the mechanical and electronic counters, and to calibrate with the requireddegree of accuracy, the standards brought into the laboratory.

Digest of paper 55-150, "A New Test Board for Portable Watt-Hour Meter Standards," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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Analysis of Errors in Sampled-Data Systems

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THE system error $\epsilon(t)$ in a sampled-data feedback system is an important design parameter. It is defined as the difference between the actual output $c(t)$ and the desired output $c_d(t)$, i.e., $\epsilon(t) \triangleq c_d(t) - c(t)$. The system error has two components: (1) organic error, due to system energy storages; and (2) ripple, due to the sampling process. Formulation of these errors is obtained through the use of z-transform[1] and ordinary Laplace transform techniques. (z-transforms are merely Laplace transforms of pulsed data and are usually rational functions in e^{sT} in which e^{sT} has been replaced by z.)

For the typical sampled-data system in Fig. 1, it is possible to describe completely the output $c(t)$ (and hence the system error $\epsilon(t)$), as a function of time. The Laplace transform of the output is easy to obtain:

$$C(s) = \frac{G(s)}{1+GH^*(z)} R^*(z) \tag{1}$$

where $R^*(z)$ is the Laplace transform of the sample input $r^*(t) \triangleq \sum_n r(nT)\delta(t-nT)$, and $GH^*(z)$ is the pulse transfer function of $G(s)H(s)$ preceded and followed by synchronous sampling switches. Symbolically this is indicated by $GH^*(z) \triangleq \mathfrak{Z}[G(s)H(s)]$. $G(s)$ is the product of the "hold" $G_h(s) \triangleq s^{-1}(1-\epsilon^{-sT})$, used for smoothing the pulse train, and the "plant" $G_p(s)$, which is the power-delivering portion of the system. As pointed out,[1] the inversion of equation 1 presents difficulties because it is rational in both s and z, for which case there are no tables available. However, a straightforward procedure exists by which equation 1 can be inverted as a function of both n and t, n representing the n^{th} sampling interval. The procedure first resolves the continuous portion of the forward transfer function (i.e., that factor which is rational in s) into its partial fractions $G_m(s) = A_m/(s + a_m)$. The output of the m^{th} partial fraction between the n^{th} and $(n+1)^{st}$ sampling instants is $c_m(t) = c_m(nT) \exp[-a_m(t-nT)]$ for which the coefficient $c_m(nT)$ can be obtained easily by inverting the z-transform $C_m^*(z)$. Summing all the $c_m(t)$ gives the complete output between sampling instants. For most feedback systems the desired output $c_d(t)$ is just the input $r(t)$, in which case the system error is

$$\epsilon(t) = r(t) - \sum_m c_m(nT)e^{-a_m(t-nT)} \tag{2}$$

Often the steady-state rather than the transient performance of the system is significant, in which case it is possible to formulate a figure of demerit based on the rms value of the system error. The input is assumed to be of the form $r(t) = e^{\lambda t}$, where λ may be complex, but is usually just $\lambda = j\omega$.

The steady-state response to this input is

$$c_{ss}(t) = \frac{\frac{1}{T}\sum_{n=-\infty}^{\infty} G(\lambda+jn\omega_0)\epsilon(\lambda+jn\omega_0)t}{1+GH^*(e^{\lambda t})} \tag{3}$$

The desired output $c_d(t)$ is taken to be the signal component of $c_{ss}(t)$, corresponding to $n=0$. For pure imaginary λ the mean square error is then given by

$$\overline{\epsilon^2} = \overline{c_{ss}^2(t)} - \overline{c_d^2(t)} = \frac{\sum_{n=-\infty}^{\infty} \left|G(\lambda+jn\omega_0)\right| - \frac{1}{T}\left|G(\lambda)\right|^2}{\left|1+GH^*(e^{\lambda t})\right|^2} \tag{4}$$

The following simple but powerful theorem gives a closed form for the summation in equation 4

$$\frac{1}{T}\sum_{n=-\infty}^{\infty} |G(\lambda+jn\omega_0)|^2 = \mathfrak{Z}[G(s+\lambda)G(-s+\bar{\lambda})]_{z=1} \tag{5}$$

where $\bar{\lambda}$ is the conjugate of λ. A good figure of demerit F for system design at a particular frequency is the per cent mean-square error, defined as the ratio of mean-square error to mean square of desired output, for which the following simplified formula is obtained:

$$F \triangleq \frac{\overline{\epsilon^2}(\lambda)}{\overline{c_d^2}(\lambda)} = \frac{T\mathfrak{Z}[G(s+\lambda)G(-s+\bar{\lambda})]_{z=1}}{|G(\lambda)|^2} - 1 \tag{6}$$

Equation 4 in conjunction with equation 5 can also be used to compute a figure of demerit for the case of stationary random inputs described by spectral densities, although the evaluation of the integrals involved will probably require numerical methods.

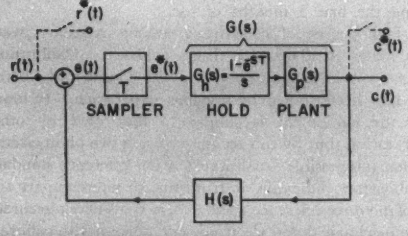

Fig. 1. Typical error-sampled feedback system. T is the sampling period

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Erection of Vertical Water-Wheel Generators

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THE TREND in the construction and erection of vertical water-wheel generators is to increasingly larger units as experience and materials permit. The machining tolerances called for become very remarkable as the sizes increase. The practices of the Canadian Westinghouse Company with approximately 9-million installed horsepower of generator experience can be used to illustrate modern construction and erection practices. (See Fig. 1.)

The machine frames are fabricated of annular steel rings with suitable spacers between, and wrapped around by a steel plate cover. The frame is bored to an accuracy within ±0.005 inch.

The accurately punched stator laminations are held firmly after stacking in the frame by heavy nonmagnetic rolled steel fingers, secured solidly by welding of the through bolts to the frame at several points.

The stator slots are carefully aligned during stacking, and the final sidewise tightening of the coil in the slot to within 10 mils is done after winding, by the insertion of mica or semiconducting plastic strips. The slot wedges on top of the coils are of nonshrinking cloth-base insulation.

Modern practice is to erect the stator by bolting the soleplates to the frame, and when positioned the soleplates are grouted in. The center line for the machine is picked up from the turbine shaft below, or from reference plugs set in the foundations by a piano-wire plumb line with a 100-pound lead weight damped in a pail of heavy oil.

Fabricated spider arms are now in common use, and tolerances of 0.003 inch on the bore and 0.005 inch on the arms are maintained. The laminated rim punchings after stacking around the spider arms are expanded by heat to insert the torque keys between it and the end of each arm.

A suspension-type spider is shrunk onto the forged steel shaft, while with the umbrella-type rotor (see Fig. 2) the thrust collar is integral with the shaft and the rotor is dowelled and bolted to the top of it.

The thrust collar at the top end of the shaft is machined to a runout of less than 0.0002 inch on the edges, and 0.0005 inch on the lower surface. The thrust bearing itself is finished with even more care, and assembled in the machine with as great care and protection from foreign matter as possible. The bearing shoes are lightly brushed with a graphite grease to make it easy to turn the rotor mechanically for final alignment of the rotor.

Fig. 1. Des Joachims Generating Station on the Ottawa River

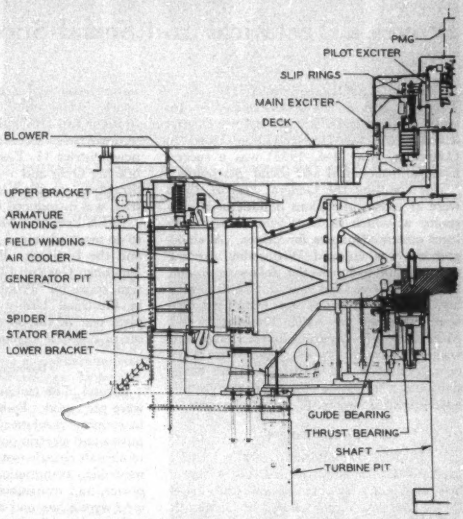

Fig. 2. Section showing the type of spider and bearing inherent in umbrella-type machine

The clearance of the adjustable-shoe guide bearings is often left at about 0.020 inch for start-up, and closed in after the initial trial runs.

With the machine assembled and mechanically aligned, it is usually given a running dry-out with the stator windings short-circuited.

Final balancing if required completes the installation. With machines running over 150 rpm, the portable dynamic balancer is useful. For slow-speed machines, the vector-analysis system is used where readings from dial indicators, running against the shaft before and after adding a trail weight, can be used to calculate the proper correction.

The modern generator has improved performance, lower losses, less weight, fewer maintenance troubles, and is easier to dismantle and reassemble for maintenance.

Digest of paper 55-162, "Production and Installation of Vertical Water-Wheel Generators," recommended by the AIEE Committee on Power Generation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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INSTITUTE ACTIVITIES

District 2 Meeting at Columbus Proves a Technical and Social Success

WITH THE COLUMBUS, OHIO, SECTION as host to 703 AIEE members, students, and guests, the Middle Eastern District Meeting (at the Deshler-Hilton Hotel in Columbus, May 4–6, 1955) was a success from both technical and social viewpoints.

Not counting the General Session, there were 21 technical sessions besides an all-day session at which students from District colleges presented papers for prizes. A smörgasbord was enjoyed Wednesday evening and a dinner-dance the following night. Luncheons were held each day of the meeting. The one on Friday was for students, who were addressed by AIEE President A. C. Monteith. The program for the ladies was varied with visits to the Ohio State University Campus, tea at the Governor's Mansion, and a tour of one of the country's oldest department stores, F. and R. Lazarus.

General Session

E. K. McCoy, chairman of the District Meeting Committee, opened the General Session Wednesday morning and introduced W. B. Morton, Vice-President of District 2, who in turn introduced Mayor M. E. Sensenbrenner of Columbus.

After the mayor's welcoming speech, Mr. Morton read two paragraphs from the May 1884 issue of *Scientific American* reporting the founding of AIEE. He compared that modest start with today's membership of nearly 50,000 and 7,000 Students in the 106 Sections and 136 Student Branches. He also told members about the establishment of the new District 11, East Central District, embracing Ohio and West Virginia. Julius C. Strassbourger, the Vice-President of this District, was introduced to the audience.

AIEE President Monteith urged members to do more advanced planning for themselves and the Institute. Philip Sporn, president, American Gas and Electric Service Corporation, spoke on "Problems and Opportunities in Electrical Utility Engineering." (Complete text of this speech appears in this issue of *Electrical Engineering*.)

Technical Sessions

A total of 88 technical and District papers were presented. Four sessions were devoted to rotating machinery; three each to computers and electric power systems; two each to aircraft electric systems, electronic aids to medicine, communication systems, atomic power, and transistors. Other subjects covered were ethics and management.

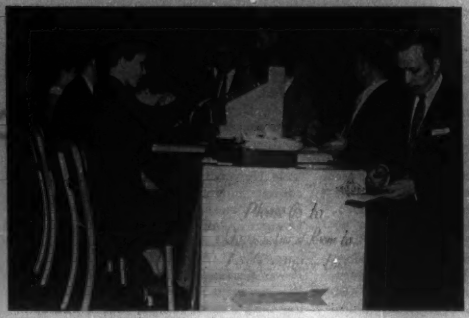
Several excellent papers were given in the sessions on electronics in medicine. F. M. Deerhake, General Electric Company, defined television as an aid for fixing the eyesight of a group of persons on an object that would be otherwise physically impossible for them to see. He also told how color television has become an important tool in the medical teaching field and how it has overcome obstacles in showing close-ups of surgical operations.

A phase of medicine, hitherto not covered at AIEE meetings, was retinal photography. This subject was covered in a paper by Prince, Cowan, and Smith of Ohio State University. Mr. Prince outlined problems of photographing retinas in color by flashlight without injuring the eyes. He showed enlargements of color photographs illustrative of different diseases. Then Mr. Smith explained the xenon lamp and the electronic circuit which controlled its half-cycle flashes.

One of the more interesting papers in the session on management was by C. J. Beller, The Cleveland Electric Illuminating Company. He analyzed the three most important management functions of a managing engineer: planning, control, and appraisal of performance. He suggested a method whereby those in managerial positions could plan ahead for the men under them as well as for themselves.

In the second session on communications systems, G. J. Harms, American Telephone and Telegraph Company, explained some of the problems which have been encountered in the transmission of color television signals between cities in the United States. Starting

INTERVIEWED on the "Touring the Town" program over WBNS-TV, Columbus, Ohio, were (left to right): Ben Harbage, chairman of the Columbus Section; W. B. Morton, District 2 Vice-President; J. W. Copening, who presented a technical paper at the meeting about advances in cinefluorography; G. E. Mueller, chairman of an Electronic Aids to Medicine session at the meeting; E. K. McCoy, general chairman of the meeting; and Theodore Savoff, who demonstrated the solar battery. Mistress of ceremonies was Virginia Trannit (center).



REGISTRATION facilities were opened from 6:00 to 9:00 p.m. on the day before the meeting and were busy throughout the 3 days of the meeting—May 4, 5, and 6. Above, members are shown receiving identification badges and programs.

CONGRATULATIONS are given to J. D. Lambert (left) and A. W. Ladd (right) by W. B. Morton, Vice-President of District 2. Lambert and Ladd were authors of the District's first prize student paper. The student paper contest was held May 6.

in 1948 with 900 channel miles, these facilities have expanded to 69,000 miles at the end of 1954. Of this total about 20,000 miles are on coaxial cable and the remainder on radio relay. He explained the differences that had to be overcome when color television signals were sent instead of black-and-white signals.

In one of the atomic power sessions, Professor C. E. Dryden, Ohio State University, presented "Opportunities for Education in Nuclear Engineering." This contained results of several surveys at 142 accredited engineering colleges concerning their participation in a teaching program of nuclear subjects. Results show that inclusion of such engineering material in the basic engineering courses ranged from 35.7 per cent by chemical engineers to 15.6 per cent for civil engineers. An accelerated growth of introductory courses in nuclear engineering was noted—an increase of 81 per cent within the past year.

In the sessions devoted to aircraft electric systems, two papers covered those systems which are unique to airships and jet fighters. One concerned an advanced concept of accessory power for guided missiles. This paper by R. L. Zimmerman, American Machine and Foundry Company, described a self-contained rocket-type gas generator system which provides electric or hydraulic power. The system uses the decomposition products of a liquid fuel as the working fluid for a high-speed hot-gas turbine. This supplies power to drive alternators, hydraulic pumps, gear boxes, or other loads.

Another paper that was of interest was that presented by O. E. Buxton, Jr., Jack and Heintz, Inc., entitled, "Environmental-Free Machines and High-Temperature Problems of Rotating Equipment." The author considered some of the various type of machines and some of the problems of their design for different flying conditions: maximum operating altitude, flight speed, ambient temperatures, operating time, duty cycle, and the length of time any of these maximum conditions might exist.

WELCOME is extended to Philip Sporn (left), president, American Gas and Electric Service Corporation, by AIEE President A. C. Monteith. Mr. Sporn delivered the principal address at the General Session, May 4.

A SMORGASBORD took place Wednesday evening in the ballroom of the hotel. Informal entertainment was provided by the Earl March Trio and the Harmonaires. Shown above are some early arrivals.

SOME OF THE CONTESTANTS in the Student Paper Contest are shown above, left to right. Front row: Charles Husson, M. A. Kraft, A. W. Ladd, G. J. McKeel, J. T. Raleigh, Rapheel Tsu, and W. T. Fryer. Back row: David Doman, R. S. Gaines, A. W. Revay, W. S. Hare, J. D. Lambert.

Student Prize Paper Contest

Fourteen students presented papers in the District 2 contest on May 6. At the student luncheon AIEE President Monteith urged them to disregard the matter of security in their jobs when first out of college and think only of the opportunity which the job offers.

In the evening, there was a student dinner at the Ohio Union on the Ohio State University Campus. Main speaker was J. L. McNealey of the Columbus and Southern Ohio Electric Company. At this dinner the following prize awards were announced:

First prize, A. W. Ladd and J. D. Lambert, University of Cincinnati, "Scatter Sounding as a Means of Instantaneous Radio Propagation Prediction."

Second prize, G. D. Haluszczynsky, Case Institute of Technology, "Automation, Industry's Growing Giant."

Third prize, J. T. Raleigh, Pennsylvania State University, "Some Aspects of Magnetic Recording."

Judges were: E. D. Ayres, H. S. Kirschbaum, and C. E. Warren of Ohio State University; J. L. Anderson and J. M. Audi of Line Material Company; and G. R. Tamplin of the Battelle Memorial Institute.

Committee Chairmen

E. K. McCoy was chairman of the District Meeting Committee, and G. M. L. Sommerman, the honorary general chairman; D. E. Stafford, treasurer, and G. R. Tamplin, coordinating secretary. Other chairmen were R. C. McMaster, advisory; L. M. Moore, administration; N. J. Greene, finance; N. A. Smith, student meeting; P. L. Gilmore, entertainment; E. E. Dreese, technical program; Mrs. P. L. Gilmore, Jr., ladies' events; C. K. Bishop, special meetings; J. W. Cade, arrangements; E. O. Wolden, publicity.

Pacific General Meeting Plans Are Near Completion

THE PACIFIC GENERAL MEETING Committee is completing plans for the forthcoming meeting in Butte, Mont., August 15–18, at the Finlen Hotel. Eighteen technical sessions presenting approximately 70 papers are being organized by the following technical committees of the Institute: Carrier Current, Transformers, Instruments and Measurements, Domestic and Commerical Applications, Transmission and Distribution, Basic Sciences, Land Transportation, Mining and Metal Industry, Cathodic Protection, Television and Aural Broadcasting, Relays, General Industry Applications, Power Generation, Industrial Power Systems, Magnetic Amplifiers, and Safety.

In addition, the following inspection trips have been announced:

Kelly Mine, Anaconda Company. This huge operation produces 12,000 to 15,000 tons of copper ore daily. This ore is hoisted to the surface through the world's largest mine shaft and is accomplished with a 3,000-hp and a 2,500-hp d-c motor, which will also be inspected.

Smelter, Anaconda Company. The smelter, near Anaconda, Mont., is supplied with ore by electric railway from Butte. Many types of electrical applications will be seen.

Several other electrical plants will be available to delegates, but these installations are located so far from Butte that special trips are considered impractical. It is suggested that delegates driving through the state contact the following people who have agreed to escort visitors through the respective plants:

Frank Bird Steam Plant, The Montana Power Company, George Scotten, Billings, Mont.; Hydroelectric Plants, The Montana Power Company, D. C. Shevalier, Great Falls, Mont.; Canyon Ferry Power Plant, U.S. Bureau of Reclamation, Project Superintendent, Canyon Ferry (out of Helena), Mont.; Hungry Horse Power Plant and Dam, U.S. Bureau of Reclamation, Bureau Headquarters, Hungry Horse, Mont.; Anaconda Aluminum Company, Reduction Plant, Carl J. Lundborg, Columbia Falls, Mont.; and Reduction Works and Wire Drawing Plant, Anaconda Company, Floyd S. Weimer, Great Falls, Mont.

Tuesday evening, August 16, will be held open for informal visiting of Virginia City. Virginia City was an early center of gold mining. Road agents, vigilantes, and "necktie" parties made front page history. Much of the original furnishings and merchandise are still in place. The Lewis and Clark Caverns can also be visited by anyone wishing to make arrangements.

District No. 1 Student Prizes and Student Counselor Activities Announced

RESULTS of the student paper competition for District 1 have been announced. Thirty dollars was awarded as first prize to Leonard A. Mende of Cornell University for "What an Engineer Should Know About Patent Law." Second prize was given to R. L. Sieron, Worcester Polytechnic Institute, for his paper, "Measurement of Stray Load Losses in Direct-Current Machines." Third and fourth prizes were won respectively by Dionysios E. Speliotis, University of Rhode Island, "Skin Effect—A Mathematical Development," and Kelvin Cook, Northeastern University, for "Analysis of a Servomechanism, Utilizing Analogue Computer."

Judges for the written contest were: M. E. C. Devine, Westinghouse Electric Corporation, Hartford, Conn.; M. B. Sprague, Southern New England Telephone Company, New Haven, Conn.; and H. M. Turner, Yale University, New Haven, Conn. Oral contest judges were: Miss Virginia N. Berndt, Blackstone Valley Gas and Electric Company, Pawtucket, R. I.; T. D. DeVore, Niagara Mohawk Power Corporation, Syracuse, N. Y.; F. B. Hunt, New England Power Service Company, Boston, Mass.; C. W. Maloney, Stone and Webster Engineering Corporation, Boston, Mass.; and H. B. McIntyre, New England Telephone and Telegraph Company, Boston, Mass.

As is customary, C. N. Hoyler of the Radio Corporation of America Laboratories invited the first three winners of the contest and their counselors to an inspection trip of the laboratories at Princeton, N. J., on May 8 and 9. (See pages 615–16.)

As for the activities of the student counselors of District 1, the following recommendations have been approved by the counselors and executive committee of the District:

1. Three annual District prizes of $30, $25, and $20 be awarded to counselors having the three highest ratios of AIEE Student members to the total of electrical engineering students

2. Three annual District prizes of $30, $25, and $20 be awarded to counselors having the three highest ratios of graduating AIEE Student members to the total electrical engineering graduating class

3. Annual certificates of merit be given to the Branches having the three highest ratios of AIEE Student members to the total electrical engineering students

4. Annual certificates of merit be given to the Branches having the three highest ratios of graduating AIEE Student members to the total electrical engineering graduating class

5. The student counselor be an ex-officio member of the executive committee of the Section nearest his Branch

6. Every Section establish a Committee on Student Branch Co-operation, consisting of the Student Branch counselor and at least two members of the Section, for: increasing the Student Branch membership, establishing friendly and close relationship between Branch and Section, promoting the local Branch speaking contest

Also, the Executive Committee of District 1 instructed Vice-President of the District, G. J. Crowdes, to recommend to the Board of Directors the approval of the following recommendations:

1. The money expended by the Member-for-Life fund for sending the winner of the District contest to the AIEE Summer General Meeting be divided among the Districts and assigned to the Vice-Presidents to spend in the interests of the Branches

2. Three national annual prizes be awarded to three student papers as follows: first prize, $100 and certificate; second prize, $75 and certificate; third prize $50 and certificate

Publicity for Research Sponsored, Backed by Engineering Foundation

Frank T. Sisco, director of the Engineering Foundation, has written:

"For more than 25 years the Engineering Foundation has been sponsoring and financially supporting research in fields of interest to the leading professional engineering societies; and, in addition, it has been contributing a considerable portion of its income from its endowment to the advancement of the engineering profession with especial attention to engineering education.

"The results of this support of engineering research and engineering education have been presented to the leading professional societies as technical papers, of importance to specialists in the fields covered by the projects; but over the years these results have not been made widely known to the engineering profession at large."

To remedy this, the Engineering Foundation Board appointed a committee on public relations which has recently been preparing short descriptive articles of some of the current projects that the committee considered of interest to engineers generally. One of these, "High-Temperature Steam Generation," follows. This particular article will probably have greatest interest for mechanical and electrical engineers, but the committee considered it of active interest in practically all branches of engineering.

It concerns the work of The American Society of Mechanical Engineers' (ASME) Committee on High-Temperature Steam Generation and shows how a major problem that cuts across the field of many companies and associations can be co-operatively attacked with widely beneficial results under the sponsorship of an organization like Engineering Foundation.

Contributions to the program from equipment manufacturers, utilities, trade associations, and Engineering Foundation are expected to reach $200,000. To this must be added the contribution of engineering services provided by the Navy Bureau of Ships for the design and fabrication of the testing equipment, which is estimated at $125,000, plus the time and effort of members of the committee and others who have spent many days in formulating the program.

Inquiries concerning the program may be addressed to Professor H. L. Solberg, chairman of the committee and head of the School of Mechanical Engineering at Purdue University, Lafayette, Ind.

"*High-Temperature Steam Generation*"

"Counter to the trend of the past decade with its steadily rising prices, the cost of electric power to the home consumer has been declining during the period while the cost to commercial and industrial users has at least not risen. For this agreeable situation the thanks of the benefited groups are largely due the research programs, which have made it possible for central station generating plants to improve their efficiency by the use of increasingly higher steam temperatures and pressures. To achieve further efficiency, however, has now become a much more difficult matter owing to two factors. The first of these factors is the severe corrosive action of high-temperature steam; the second is the lack of metallurgical stability of the materials available for superheater tubing.

"The corrosion problem has been under attack for a number of years. Between 1936 and 1942 a special research committee of the ASME sponsored work on it at Purdue University. This research, which was financed by Engineering Foundation, Purdue University, and industry, was discontinued during the war. It was re-established in 1949 as a project to study the possibility of using a regenerative steam cycle at temperatures up to 1,650 F.

"Four factors are being studied at the present time: the properties of the oxide films formed on steel exposed to high-pressure steam at temperatures between 1,100 and 1,500 F; the resistance of superheater steels to the gases encountered with commercial fuels; the metallurgical stability of the materials during high-temperature service for periods up to 3 years; and the effect of repeated thermal shock.

"Laboratory tests with synthetic atmospheres have been completed, as have field tests in 11 different generating units. According to these tests, several available steels are capable of satisfactory service when delivering steam at temperatures up to 1,200 F—except when certain types of residual oils and waste fuels are burned.

"New tests that promise to be widely significant will be made at the Philip Sporn Plant of the American Gas and Electric Company, where steam is available at 2,000-psi pressure and 1,000 F temperature. For these tests, special apparatus has been designed in co-operation with the U. S. Navy Bureau of Ships. Electric superheaters and counterflow heat exchangers will be installed in the plant to provide the required steam temperatures. This steam will be passed through five test racks of identical design. Racks one and two will contain specimens of selected ferritic steels maintained at 1,100 and 1,200 F, respectively. In the other three racks there will be specimens of selected austenitic steels, which will be held at 1,200, 1,350, and 1,500 F.

"It will be some 5 or 6 years before the test program at the Sporn plant can be completed, as exposure of the specimens to high-temperature steam for a minimum of 3 years is necessary.

"The effect on heat transfer of the corrosion products formed by steam on the inside of steel tubes is now being studied in special equipment designed and installed at Purdue University. In this project, steam is passed through a counterflow heat exchanger and electric superheater connected in series, which will deliver steam at 1,000 F. The steam is then passed through two identical

Future AIEE Meetings

Pacific General Meeting
Butte, Mont.
August 15–19, 1955
(*Final dates for TP*—closed, CP‡—closed*)

Petroleum Technical Conference
Shamrock Hotel, Houston, Tex.
September 12–14, 1955
(*Final date for submitting papers—closed*)

AIEE-ISA Instrument Conference
Shrine Auditorium, Los Angeles, Calif.
September 12–16, 1955
(*Final date for submitting papers—closed*)

AIEE-IRE Industrial Electronics Conference
Rackham Memorial Auditorium, Detroit, Mich.
September 28–29, 1955
(*Final date for submitting papers—closed*)

1955 Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 3–7, 1955
(*Final dates for TP—closed, CP—August 3*)

Motor Application and Problems in Heating and Cooling Conference
St. Louis, Mo.
October 18–20, 1955
(*Final date for submitting papers—July 18*)

Aircraft Electrical Equipment Conference
Hollywood Roosevelt Hotel
Los Angeles, Calif.
October 25–27, 1955
(*Final date for TP—July 11, CP—Aug. 25*)

EJC-AIEE Nuclear Energy Conference
Cleveland, Ohio
December 12–16, 1955
(*Final date for submitting papers—September 12*)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 30–February 3, 1956
(*Final date for TP—Oct. 20, CP—Nov. 30*)

South West District Meeting
Dallas, Tex.
April 2–4, 1956
(*Final date for TP—Jan. 3, DP†—Feb. 2*)

Great Lakes District Meeting
Fort Wayne, Ind.
April 16–18, 1956
(*Final date for TP—Jan. 16, DP—Feb. 16*)

North Eastern District Meeting
Rochester, N. Y.
May 2–4, 1956
(*Final date for TP—Feb. 1, DP—Mar. 2*)

*TP—Transactions papers
†DP—District papers
‡CP—Conference papers

heat exchangers in series, one of which contains a clean tube and the other a corroded tube of the same steel. By measuring the flow and the temperature rise through the two heat exchangers in series, the effect of the scale on heat transfer can be determined. The thickness of the scale and its metallurgical characteristics will also be determined."

Second Petroleum Industry Conference Planned; Authors Invited to Present Papers

ELECTRICAL ASPECTS of the production, refining, and transportation fields in the petroleum industry will be presented at the second Electrical Conference of the Petroleum Industry. Sponsored by the Petroleum Industry Committee and the Houston Section of AIEE, the meeting is planned for September 12, 13, and 14, 1955, at the Shamrock Hotel, Houston, Tex. The conference sessions will be open to all interested persons.

CONVENTION FACILITIES have been inspected by committee members for the second Electrical Conference of the Petroleum Industry at the Shamrock Hotel, Houston, Tex. The meeting will take place next September 12–14. The committee is shown above beside the hotel pool. Seated (left to right): R. S. Gardner, headquarters representative; H. M. Stewart, conference chairman; J. Z. Linsenmeyer, chairman, AIEE Committee on Petroleum Industry; and E. A. Clarke, chairman, printing and programming committee. Standing (left to right): M. T. Robin, chairman, regional publicity committee; O. A. Boyer, member-at-large; A. J. Zavada, chairman, inspection trips and transportation; R. S. Cannon, chairman, Transportation Subcommittee; J. R. Ashley, chairman, Production Subcommittee; W. H. Dickinson, chairman, Refining Subcommittee; W. E. Silvus, chairman, finance and budget; H. J. Kongabel, conference vice-chairman; and J. C. Gardner, chairman, registration and hotel arrangements.

A large banquet is planned for the second evening and the speaker is to be of national importance and have a keen interest in the petroleum industry. Field trips to nearby installations also will be offered in conjunction with the meeting.

Authors desiring to present papers or discussions should write to J. Z. Linsenmeyer, Chairman, Committee on Petroleum Industry, in care of the Westinghouse Electric Corporation, P. O. Box 1017, Pittsburgh 30, Pa., or to R. S. Gardner, Assistant Secretary, Technical Committee Activities, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

H. M. Stewart, Humble Oil and Refining Company, Baytown, Tex., has been named conference chairman. Harold J. Kongabel, Westinghouse Electric Corporation, Houston, Tex., is this year's conference vice-chairman.

Last year the first conference was held in Tulsa, Okla., and was attended by 389 engineers from 22 states and Canada.

First Father and Son to Hold Membership for Life

The first father and son to hold AIEE Membership for Life are Cyril M. Jansky, Sr., and Cyril M. Jansky, Jr. This happened on May 1 when Mr. Jansky, Jr., 55, completed 35 years as a member of the Institute. His father, Cyril M. Jansky, Sr., 85, was made a Member for Life 15 years ago. Both have achieved distinction in the electrical engineering profession for many years. The elder Mr. Jansky is professor emeritus of electrical engineering, University of Wisconsin (Madison). His son is a founder and chairman of the board of Jansky and Bailey, Inc., Washington, D. C., radio consulting engineers.

Professor Jansky was born in Richland County, Wis., March 15, 1870. He is a Fellow of the AIEE, a former president of the Institute of Radio Engineers, and a member of the Prague Society of Physics and Mathematics. He received his bachelor of arts degree from Valparaiso University, Indiana, in 1891 and his master of science degree from Michigan University (Ann Arbor) in 1904.

He was with the Bureau of Standards before entering the teaching profession as acting dean of the School of Applied Science at Oklahoma University in 1905. In 1908 he became professor of electrical engineering at Wisconsin and retired in 1940.

The younger Mr. Jansky was born in Delton, Mich., June 28, 1895. He received both his bachelor of arts and master of arts degrees from the University of Wisconsin. He is a fellow of the Institute of Radio Engineers.

He was a member of the electrical engineering faculty at the University of Minnesota from 1920 until 1928 when he returned to enter private consulting practice. He was a founder of the firm of Jansky and Bailey in 1930. Engaged in the development of sound broadcasting and other radio fields since 1920, he was a member of the four Hoover Radiotelephone Conferences, 1922–26. He was also a United States delegate to the General International Conference dealing with radio regulation and electronic aids to marine navigation. He was a special consultant to the Secretary of War in 1942 and 1943 and received certificates of appreciation from the U.S. Army and Navy for outstanding contributions to the work of the Office of Scientific Research and Development during World War II.

Tesla Centennial Proposed for Next Year

In an editorial, "Strange Genius," published in *Power*, May 1955, attention is directed to an early Member of AIEE, Nikola Tesla, and his work which had a profound effect on the future of electrical engineering.

He was author of a paper entitled, "A New System of Alternate Current Motors and Transformers," presented before a general meeting of the Institute on May 16, 1888, and recorded in the AIEE *Transactions*, vol. 5, pp. 308–24—with more than three pages of discussion. In this paper Tesla described a new a-c system that had as its heart the induction motor with its basic concept of the rotating magnetic field.

For Tesla, this was only a beginning. Still to come was his work on high frequencies which consisted of thinking basic to much of the radio art of today. Yet when he died in 1943, he and his work had almost been forgotten. Why?

Quoting from the *Power* editorial in answer, "A man of flashing insights and enormous intelligence, Tesla was largely indifferent to the development of his ideas. This he left to others while he followed the lure of new challenges. In later years, his projects became more grandiose, his ways more mysterious, his pronouncements more Olympian. And working alone, as he did, he formed none of the institutional ties that help to perpetuate a record of accomplishment.

"Next year—July 10, 1956—will be the 100th anniversary of Nikola Tesla's birth.

It would be fitting for our engineering societies to commemorate this occasion, to acknowledge our debt to this strange and lonely genius who changed our world for the better."

Inasmuch as Nikola Tesla was a Vice-President of AIEE (1892–94) and the Edison Medalist of 1916, it would seem most appropriate that the AIEE take cognizance next year of the centennial of this remarkable man's birth.

1,200 At Electronic Components Conference; Proceedings Available

Twelve hundred electronic engineers gathered May 26 and 27 in Los Angeles, Calif., at the Ambassador Hotel for the Sixth Annual Electronic Components Conference, which is staged alternately on the East and on the West Coasts. The conference is sponsored jointly by AIEE, Institute of Radio Engineers, Radio-Electronics-Television Manufacturers Association, and the West Coast Electronics Manufacturers Association.

In the Los Angeles symposium, a total of 56 technical papers were presented in eight technical sessions during the 2-day meeting. Such subjects as power transistors, component application and reliability, and new semiconductor devices made up session topics.

In addition, there were outstanding luncheon addresses on each of the two days, by Dr. Ivan Getting, Raytheon Manufacturing Company, and L. C. Hyland, Hughes Aircraft Company. Dr. Gettings' topic was "The Increasing Need for New Components." He outlined the growing demand for components of completely new types, to be designed to do jobs never before attempted.

Mr. Hyland spoke on "The Component Future," which concerned the research, development, and production challenges that are ahead for the electronics industry.

A debate, in which four of the nation's leading electronics spokesmen discussed "Tubes vs. Transistors," took place May 26. Dr. Harper North, Pacific Semiconductors, and Dr. Louis Ridenour, Lockheed Aircraft, spoke for transistors, opposing Dr. W. R. G. Baker, General Electric Company, and Lt. Gen. C. S. Irvine, Deputy Chief of Staff, Materiel.

Complete proceedings of the 1955 Electronic Components Conference may be ordered by addressing the AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

District 6 Student Branches Meet, Hold Conference Apr. 22–23

The District No. 6 Student Branch Conference was held at the South Dakota School of Mines and Technology, April 22 and 23. Participating schools were the Colorado Agricultural and Mechanical College, University of Colorado, University of Denver, South Dakota School of Mines and Technology, University of Wyoming, and the University of Nebraska. Eleven papers were presented by students at the conference and the winning papers of the competition were announced at the evening banquet by Vice-President A. S.

AIEE Fellow Honored by San Francisco Section

"FOR LEADERSHIP in solution of inductive co-ordination problems and in the field of communications engineering," Thomas Taylor receives his certificate as Fellow in the AIEE. The certificate was presented at a recent dinner meeting of the San Francisco Section. Mr. Taylor is chief engineer, The Pacific Telephone and Telegraph Company, San Francisco, Calif. (For his biography, see pages 353–4 of the April *Electrical Engineering*). Congratulations are given by D. I. Cone (right), AIEE Director, and Wilbur Howe (left), San Francisco Section chairman.

New Building to Be Inspected by Members

A SCALE MODEL of the new Prudential Building, Chicago, Ill., is shown. This $40,000,000 structure will be among the inspection trips scheduled for the Fall General Meeting of AIEE, October 3–7. It has the highest electrical design load of any building in the United States, the fastest high-rise elevators in the world, and also the highest intensity lighting. Headquarters for the meeting will be at the Morrison Hotel.

(Credit, Hedrich-Blessing, Chicago)

Anderson. They were as follows: "Miniaturization of Geiger Counters," first prize, John Sparks and Robert Bergman, University of Wyoming; "The Transistor and Its Application," second prize, D. J. Neale, University of Denver; "Computers," third prize, William D. Gutscher, Colorado Agricultural and Mechanical College.

Judges for the written papers were: P. T. Baird, A. G. Johnson, and M. I. Risley, members of the Nebraska Section of the AIEE. Judges for the oral presentation were: C. L. Gust, R. O. Asheim and D. O. Flahart, members of the Black Hills Subsection of the Denver Section.

Vice-President Anderson presided at the business meeting of counselors and incoming Student Branch chairmen held Saturday morning, April 23. Professor Paul H. Lindon, counselor for the Colorado Agricultural and Mechanical College Student Branch, was elected District No. 6 chairman of the Committee on Student Activities for next year.

MINIATURE GEIGER COUNTER is demonstrated by John Sparks (left) and Robert Bergman, coauthors of the first prize paper in District 6's Student Paper Competition. Both students represent the University of Wyoming Branch.

New Hampshire Section Holds Final Meeting of the Year

The final meeting of the year of the New Hampshire Section was held May 11. Featured at the meeting was Ray Moeller, commercial engineer of the Meter and Instrument Divisions of the General Motors Company. Mr. Moeller's topic was, "Around the World Under Sail." He described the 18-month's world cruise of Johnson's brigantine *Yankee* to 103 ports.

Retiring Section Chairman Roger Hunt introduced the incoming officers for the 1955–56 season. L. M. Partridge will be the new chairman and Floyd H. Busch vice-chairman. Richard A. Nichols was re-elected secretary-treasurer and his assistant will be J. H. Spencer. Newly elected members of the executive committee are: W. B. Nulsen and W. O. Pennell. H. J. Ellis and D. F. Carlisle will continue on the executive committee with senior past chairman Fred Austin and junior past chairman R. W. Hunt. Retiring members of the executive committee are L. W. Hitchcock, R. T. Lord, and J. C. Robinson.

Also, Leonard E. Bernier, retiring chairman of the Student Branch at the University of New Hampshire, was presented with first prize money and a certificate as the winner of the prize paper contest, April 15. Donald W. Melvin received second prize.

The judges from the Section were: Richard T. Lord, New Hampshire Electric Company; Ernest T. Parsons and Floyd H. Busch of General Electric Company.

Professor Alden L. Winn, chairman of student relations for the Section, introduced Stanley A. Dabrowski, incoming chairman of the Student Branch.

5 Winners for District 5 Student Paper Competition

The Annual District 5 Student Paper Competition was held in Milwaukee, Wis., at the District 5 Conference on Student Activities, May 12–14. Serving as hosts for the

INCOMING CHAIRMAN L. M. Partridge, New Hampshire Section, chats with Ray Moeller, guest speaker (center), and R. W. Hunt, outgoing chairman, at the May 11 Section meeting. Mr. Moeller is commercial engineer, Meter and Instrument Divisions, General Motors Company.

RETIRING CHAIRMAN of the Student Branch at the University of New Hampshire L. E. Bernier (left), incoming Branch Chairman S. A. Dabrowski (center), and Professor A. L. Winn, chairman of student relations, New Hampshire Section, were also at the meeting.

meeting were the AIEE Student Branches of Marquette University and the Milwaukee School of Engineering. Undergraduate students from 17 schools in the District presented papers.

In the undergraduate competition, first place was awarded to James C. Trieble, Marquette University, for "Unipolar Generators, Theory and Development." Charles Roth, University of Minnesota, took second place honors with "The Tic-Tac-Toe Machine." "Synchronous Demodulation and Dual Channel Reception" won third place for Richard Reid of Iowa State College.

On the graduate level, John J. Jones, University of Notre Dame, won first place for "Phase Plane Analysis of Sampled Data Systems." Robert W. Greer, University of Wisconsin, received second place for "Phase Angle and Root Loci Analysis of Sampled Data Systems."

LOOKING AT THEIR CHECKS are winners of District 5's Student Paper Competition. Seated left to right: R. W. Greer, second place winner, graduate competition, University of Wisconsin; J. C. Trieble, first place, undergraduate competition, Marquette University; R. J. Reid, third place, undergraduate competition, Iowa State College. Standing left to right: Howard Brem, one of the oral contest judges and past chairman, Milwaukee Section; E. L. Fairchild, chairman, District 5 Student Activities Committee; C. M. Summers, Vice-President, District 5; and C. R. Schultz, Secretary, District 5.

AIEE's Pittsburgh Section Celebrates 52d Anniversary

Four-hundred forty persons attended Pittsburgh Section's 52d Anniversary Dinner Meeting, April 19. Eighty of these were AIEE Student members.

The dinner meeting ended a busy day of activities centered around the Student members. The students had attended a conference at the Mellon Institute and later toured the Irvin Works of the United States Steel Company.

At the dinner, prizes were awarded as part of the District prize paper contest. Fifty dollars, the first prize, went to James T. Raleigh of Pennsylvania State College for "Some Aspects of Magnetic Recording." The second prize of $25 went to Andrew W. Revay of the University of Pittsburgh.

Guest speaker was Dr. Guy Suits, vice-president of research and director of the General Electric Company. His talk was "Laboratory Production of Diamonds." This was a review of man's effort to duplicate nature's hardest substance and led to General Electric Company's recent achievements in this field. (See pictures below.)

Baltimore Section Hears Talk on High Fidelity

At the April meeting of the AIEE Baltimore Section, Charles Wilkins, assistant to the chief engineer of the David Bogen Company, presented a paper entitled "High-Fidelity Music Reproduction by Electronic Means." This paper dealt with the general problems involved in obtaining realism in music reproduction. Also, Mr. Wilkins demonstrated his firm's latest equipment.

AIEE Student Winners Visit NBC and RCA

District Winners of the Institute's Prize Paper Competition toured the National Broadcasting Company (NBC), New York, N. Y., and also visited the David Sarnoff Research Center of the Radio Corporation of American (RCA), Princeton, N. J., May 8 and 9. (See picture of the students at the research center on the following page.)

At Princeton, the group was welcomed by Dr. Douglas H. Ewing, administrative director, RCA Laboratories, and met with leading members of the laboratory staff.

CELEBRATING Pittsburgh Section's 52d anniversary, April 19, were 440 persons. Eighty of these were AIEE Student members. The picture at the left shows some of those who attended. The speaker's table is in the background. Guest speaker C. G. Suits, vice-president and director of research of the General Electric Company, is shown in the picture at the right (standing). Seated are (left to right): S. L. Drum, executive vice-president, West Penn Power Company; E. S. Reeser, chairman, Pittsburgh Section; E. C. Bain, vice-president, research and technology, U. S. Steel Corporation; P. D. Carmichael, Student Branch Conference chairman.

DISTRICT WINNERS of the Institute's Prize Paper Competition are shown at the David Sarnoff Research Center of the Radio Corporation of America (RCA), Princeton, N. J., May 9. Students also visited the National Broadcasting Company. At left is C. N. Hoyler, manager of technical relations, RCA Laboratories, displaying an early television tube made by Dr. V. K. Zworykin in 1931. Students are (front row, left to right): J. D. Lambert, A. W. Ladd, University of Cincinnati; Richard Wolfson, New York University; and (back row, left to right) H. P. Le Fevre, Manhattan College; Arvin Grabel, New York University; R. L. Sieron, Worcester Polytechnic Institute; G. D. Halusczczynsky, Case Institute of Technology; J. T. Raleigh, Pennsylvania State University; and Dionysios Speliotis, University of Rhode Island.

Their visit included inspection of research facilities and demonstrations of recent electronic developments.

This is the fourth year the AIEE Prize Paper winners have visited NBC and the David Sarnoff Research Center under RCA sponsorship.

Lehigh Valley Section Holds Annual Safety Meeting

Do it yourself activities at home have increased home accidents to such an extent that they may soon out-number industrial accidents. This was mentioned by James E. O'Neil at the Lehigh Valley Section's annual Safety Meeting, April 15. Mr. O'Neil, director of Industrial Service, National Society for Prevention of Blindness, gave a talk, "The Positive and Negative of Safety." He stressed the development of good safety habits both at home and at work. He said that people can reduce the number of home accidents by taking home safety habits learned at their place of employment.

J. J. Smith, president of the Northeastern Pennsylvania Optometric Association, showed a film, "To Live in Darkness." He later described the orthorater, a machine used for detecting various eye defects.

Seattle Section Is Host to Washington University Branch

Seattle Section members were hosts to the University of Washington Student Branch at the Section's annual banquet, April 28. H. R. Loew, Seattle Section vice-chairman, presided and 35 students from the University of Washington attended. One hour was spent before dinner in becoming better acquainted with the students. Peter Schoening, experienced mountain climber, lecturer, and chemical engineer, showed slides of his experiences in the conquest of King's Peak, Alaska.

Since this banquet was very successful, the Section plans to make it an annual event.

THE ANNUAL SAFETY MEETING of the Lehigh Valley Section was held April 15 in Scranton, Pa. Essential to the meeting's success were (left to right, standing): A. W. Plonsky, publicity committee; W. F. Dunkle, Section vice-chairman; J. W. Gehrke, Scranton Division manager; H. Landsman, membership committee; D. H. Jackson, meetings and papers committee; J. W. Mills, attendance committee. Seated left to right are: Speakers J. J. Smith, J. E. O'Neil, and Section Chairman D. L. Greene.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Industry Division

Committee on Mining and Metal Industry (*W. R. Harris, Chairman; R. B. Moore, Vice-Chairman*). Committee activities during the past year have been devoted almost entirely to the organization and presentation of technical papers at General meetings. The Metal Industries Subcommittee has carried on co-ordinated activity with the American Iron and Steel Institute (AISE), the objective being to reach informal agreement on proper scope of AISE and AIEE with respect to technical paper coverage. The Eastern Mining Subcommittee has continued close liaison with the Underground Power Committee of the American Mining Congress (AMC) and several persons participating both in AIEE and AMC have assisted materially in this endeavor.

Throughout the Committee on Mining and Metal Industry there has been increased emphasis on technical papers of high quality. It is believed that AIEE papers should be directed primarily toward electrical engineers in the mining and metal field, whereas papers prepared for AISE and AMC should be less technical in nature from an electrical standpoint and should be directed principally toward operating and management people in the industries.

Power Division

Committee on Switchgear (*J. D. Wood, Chairman; J. C. Woods, Vice-Chairman; K. J. C. Falck, Secretary*). The Committee on Switchgear has undertaken the preparation of standards for fuses 600 volts and below. A comprehensive study of existing standards for fuses in this voltage has been made. Many forms of the fuses as now available on the market, such as the modern current-limiting fuse, are not adequately covered.

A working group under the chairmanship of J. C. Lebens will prepare standards which will supplement existing standards and be applicable to the higher current ratings and the higher interrupting ratings.

Committee on Transformers (*J. A. Adams, Chairman; J. R. Meador, Vice-Chairman; M. H. Pratt, Secretary*). At a meeting in Cleveland, Ohio, April 1, 1955, the committee approved a proposed "Test Code for Power Factor Testing of Distribution Transformers." Also, revisions were proposed for the dielectric test tables covering dry-type transformers, instrument transformers, and induction and step-type regulators. These

Michigan Section Honors Past Chairmen

PAST CHAIRMEN of AIEE's Michigan Section were honored at a dinner, April 12. Also, newly elected officers of the Section were presented. Past chairmen shown above are (left to right): A. A. Meyer (1916–17), A. S. Albright (1921–22), J. H. Cannon (1922–23), L. Braisted (1930–31), J. J. Shoemaker (1931–32), O. E. Hauser (1932–33), J. R. North (1934–35), and H. P. Seelye (1935–36). Back row (left to right): S. S. Attwood (1936–37), D. H. Baker (1937–38), R. E. Greene (1938–39), W. Knickerbocker (1939–40), M. B. Stout (1942–44), L. W. Clark (1945–46), G. M. Shute (1946–47), E. F. Dissmeyer (1949–50), I. B. Baccus (1951–52), A. P. Fugill (1952–53), and H. E. Crampton (1953–54).

Eta Kappa Nu Honors New AIEE President

HONORARY MEMBERSHIP in Eta Kappa Nu, Gamma Kappa Chapter, Newark College of Engineering, Newark, N. J., was presented to incoming AIEE President Morris Hooven (second from left), April 26. Charles Deininger (far right), senior electrical student and president of Eta Kappa Nu at the college, presented the certificate. Another AIEE member, Solomon Fishman (left, M '34), associate professor of electrical engineering at the college, received honorary membership, as did Henry Jasik (second from right, not an AIEE member). Faculty adviser to the chapter is Professor R. E. Anderson (M '48), associate professor, electrical engineering.

New York Section Visits Railroad Company

ON DISPLAY are one of the New York, New Haven and Hartford Railroad Company's new rectifier-equipped locomotives (right) and multiple-unit cars (left). About 65 AIEE members and guests attended an inspection trip at the company's Van Nest Shops located in the Bronx Borough of New York, N. Y., May 7. The trip was sponsored by the Transportation Division of AIEE's New York Section.

proposals will be submitted to the Standards Committee for further action.

A proposed test code for temperature-life tests of ventilated dry-type transformers has been prepared for discussion at the Summer General Meeting. It is an attempt to apply to ventilated dry-type transformers the recommendations for evaluating insulation systems as suggested in AIEE no. 7, "General Principles Upon Which Temperature Limits Are Based in the Rating of Electric Machines and Other Equipment." Tests are proposed for either actual transformers or models.

A test code for current-limiting reactors has been prepared. Also, separate test codes for other specific types of equipment are being developed to replace the present test code which is concerned primarily with power and distribution transformers.

The Insulating Fluids Subcommittee is preparing a guide on insulating oils which will cover circuit breaker oils as well as transformer oils.

The recently established West Coast Subcommittee has held two meetings in San Francisco this year and is actively engaged on transformer problems. It is expected that proposals and suggestions from this subcommittee will be of considerable value to the main committee.

A new project under investigation by a working group of the committee is the use of impedance-bridge methods for measurement of transformer losses.

Committee on Protective Devices (*E. G. Norell, Chairman; E. M. Hunter, Vice-Chairman; K. H. Kidd, Secretary*). A working group under the Subcommittee on Fault Limiting Devices has been preparing a report, "Factors Concerned with the Use of Protective Devices Shunting Current Limiting Reactors" and has now completed investigations on the protection of both series and neutral grounding reactors. The work of this group was divided into several separate investigations:

1. A questionnaire was sent to 45 power companies requesting information on troubles which have been associated with the use of current limiting reactors.
2. A detailed study was made of the application and experience records on current-limiting reactors as applied to industrial firms.
3. Failures involving reactors and cables in Havana, Cuba, were analyzed.
4. A general study was made of transient overvoltages due to arcing grounds on circuits involving current-limiting reactors.
5. Experience with forced current zero and investigations of faults through solid dielectrics were reviewed.
6. Requirements for protection of neutral grounding reactors were studied.

A final report on this subject will be presented at the Summer General Meeting in Swampscott, Mass.

A working group has been organized under the Subcommittee on Lightning Protective Devices to review the status of information on lightning protection of multicircuit substations. For a given assumed incoming surge to a station the additional lines connected to the bus reduce the steepness of the front of the wave and effect the permissible distance between the arrester and the transformer. The added lines also reduce the magnitude of any incoming surge. It is hoped this group can evaluate the effect of the additional lines and furnish information to assist in the application of lightning arresters on multicircuit substations.

An investigation of switching surges is being undertaken as a joint effort by representation on a working group of the Transmission and Distribution General Systems Subcommittee. Lightning arresters are involved in that the switching surge voltage may be high enough to spark over the arrester gap and discharge long-duration surge currents. The arrester protective characteristics under such surge discharges determine the stress on apparatus insulation on long-duration voltages. The nature of the current discharge determines the duty on the arrester.

A working group has also been organized on surge protection of rotating machinery. A number of papers have been written on this subject and the basic idea in back of machine protection is to slope off the front and to limit the stress of surge voltage. One of the problems is the correct evaluation of the circuits and the protective capacitors to properly slope off the wavefront. A second problem is in magnitude of the impulse-level machine insulation. Past practice has indicated that this impulse strength is the crest of the original 60-cycle test voltage, but recent papers have indicated that a higher impulse strength can be assumed. Information will also be obtained by this working group on surge transfer through transformers.

District 7 Student Winner Announced

PAST AIEE VICE-PRESIDENT C. Myron Lytle, 1952–54, (left) presents District 7's cup to the winner of the District student paper competition, Morton L. Mullins (right). Mr. Mullins represented the Student Branch at the School of Mines, University of Missouri (Rolla). The cup was donated to the District by the Branch at the University of Kansas (Lawrence) and will be presented to future winners each year. The contest was held at the University of Kansas, April 15–16.

AIEE FELLOWS ELECTED..

Board of Directors Meeting, April 14, 1955*

Bristow Guy Ballard (AM '33, M '44), director of the Radio and Electric Engineering Division of the National Research Council (NRC), Ottawa, Ont., Canada, has been transferred to the grade of Fellow in AIEE "for his contribution in applying electrical engineering technology to problems of national defense." Mr. Ballard was born in Fort Stewart, Ont., June 19, 1902. He was graduated from Queens University where he received his electrical engineering degree in 1924. Following graduation he attended a Westinghouse graduate electrical engineering course in East Pittsburgh, Pa. In 1925 he entered the engineering department of the

*The Board of Directors approved several other transfers to Fellow grade at the April 14 meeting. These will appear in a succeeding issue.

company where he remained for the next 5 years. In 1930 he joined the National Research Council of Canada and assumed charge of the electrical engineering laboratory. In 1948 he was made director of the Radio and Electrical Engineering Division. Mr. Ballard has greatly expanded the activities of the division since becoming director. Work is now under way on such diversified projects as radioastronomy, long-distance propagation of 10-cm waves, electronic aids to navigation, dielectric and semiconductor research, high voltage, electromedical research, antenna development, high-frequency standards, and other projects which are classified. He has about 80 engineers, mathematicians, and physicists under his direction, as well as a number of fellowship students who are conducting postdoctorate studies. In 1954 he was appointed vice-president, scientific, of the NRC. During World War II his activities were largely devoted to the development of mine sweepers for enemy magnetic mines and the protection of ships against these mines. Most of this work was undertaken in Ottawa and later applied to equipment on both the East and West Coasts, as well as on the high seas. In recognition of his contributions in this field, he was awarded the Order of the British Empire in 1946. He is a past chairman of AIEE's Ottawa Section and at present is a vice-president of the Engineering Institute of Canada. He is also a fellow of the Institute of Radio Engineers and a member of the Association of Professional Engineers of the Province of Ontario and of the Professional Institute of the Public Service of Canada, a director of the Canadian Standards Association and chairman of its Approvals Administrative Board, past president of the Canadian National Committee of the International Electrotechnical Commission, and a member of the Steering Committee of the Dust Problem Committee (to study causes and prevention of dust explosions in grain elevators). He has served on the following AIEE committees: Research (1946–55) and the Standards Committee (1953–55).

Roy Leo Brown (M '42), manager, Instrument and Regulator Division, Westinghouse Electric Corporation, Sharon, Pa., has been transferred to the grade of Fellow in the AIEE "for contributions to the theory, design, and technical advancement of transformers in the power field." Mr. Brown was born February 17, 1896, in Hamler, Ohio. He obtained his bachelor of science degree in electrical engineering from Ohio State University in 1922. His entire professional career has been devoted to the theory, design, and application of transformers, regulators, and related apparatus with the Westinghouse Electric Corporation. In 1922 he served as a design engineer in the power transformer section. In this capacity he was responsible for design and correct interpretation of consumers' requirements on certain commercial orders for the largest power transformers made by Westinghouse. In the company expansion program of 1925 he was sent to the newly acquired transformer plant at Sharon. Thus he was on the "ground floor" of operations there. In 1926 he was active in developing the idea of using subdivided conductors in the windings resulting in greatly reduced costs on large power transformers. From 1928–37 Mr. Brown was active in a specialized group of engineers assigned to developing standard insulation to be used in large power transformers. His studies resulted in the use of a radically new method of applying insulating spacers in shell-type transformers, as well as a simplification of manufacturing drawings. This resulted in much saving of cost. He also conceived the idea for the sudden-pressure relay and the form-fit tank for shell form transformers in 1937. Other patents credited to him during this period were: an improved tongue wedge for shell-type transformers, 1931; application of air blast to Westinghouse radiators, 1935; and transformer tank structure, 1938. His application of air blast to radiators made possible more than before the use of increased kilovolt-ampere capacity in transformers and led to the introduction of triple-rated transformers. His patents were incorporated to a large extent in the actual design and manufacture of power transformers during this and subsequent years. In 1937 he was named to head an entirely new engineering group devoted to analyzing and compiling means of reducing manufacturing costs. He became a section engineer in cost reduction engineering having responsibility for the activities of three cost engineers. The scope of activity was plant-wide. His counsel was sought during this period in teaching certain phases of transformer design to new student engineers. He contributed further ideas in the lowering of transformer costs by proving that it was practical to reduce the number of high-low spaces in the internal construction of transformer windings. His fostering of the use of paper-insulated cable was proved practical and is used today on a plant-wide basis. Also during this period Mr. Brown obtained a patent on a transformer case with internal base reinforcement. In 1941 he was promoted to section manager in large power transformer design. He was not only responsible for activities of about 20 engineers and 40 draftsmen, but for the success of many new methods which he himself conceived during his period as a development engineer. In 1949 he became manager of the Instrument and Regulator Division at Sharon. There he became responsible for the activities of three entire sections, each equivalent in importance to the section he managed from 1941–49. These were: the regulator section, the instrument section, and the auxiliary apparatus section. His responsibilities multiplied to include about 52 engineers and about 75 draftsmen, clerks, and stenographers. He was elected chairman of AIEE's Sharon Section, 1947–48. In 1952 he became a member of the AIEE Transformer Committee and in 1953 was named chairman of the Working Group on Revision of Guides for Loading Oil-Immersed Transformers, an office he still holds. A biography of Mr. Brown has appeared in "Who's Who in Engineering" since the 1948 edition. Mr. Brown has served on AIEE's Transformer Committee (1952–55) and Substations Committee (1954–55).

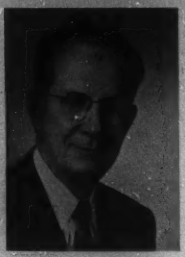
Thomas Henry Granfield (AM '19, M '27, Member for Life), assistant vice-president, engineering, Northwestern Bell Telephone Company, Omaha, Nebr., has been transferred to the grade of Fellow in AIEE "for skill in handling the engineering problems of an important communications enterprise, and for leadership in the development and great enlargement of its engineering organization." Mr. Granfield was born in Pittsfield, Mass., September 1, 1890. He received his bachelor of science degree in 1914 from the University of Minnesota and also did some graduate school study before entering the U. S. Army. Before graduation from the University of Minnesota, he did various assignments during summer vacations in the transformer engineering department of the General Electric Company. From 1914–15 he was with the insulation testing laboratory of General Electric. He joined the Northwestern Telephone Exchange Company, Minneapolis, Minn., in 1916 where he did miscellaneous plant and engineering department assignments. For 2 years, 1917–19, he was with the U. S. Army, Signal Corps and Air Force. His career with the Northwestern Bell Telephone Company began in 1919 when he finished Army service. He was a toll engineer for the company at St. Cloud, Minn. He later transferred to the Northwest Division, Minneapolis. Then he became interference engineer at the general

B. G. Ballard

R. L. Brown

T. H. Granfield

office, Omaha, in 1920, where he developed, directed, and supervised engineering plans for inductive co-ordination of power and telephone lines for harmonious relationships over a 5-state area. He then succeeded to the following positions at that office: engineer of costs and practices, 1925–28; inventory and costs engineer, 1928–39; engineering and plant operations supervisor, 1939–40; engineering supervisor, 1940–42; inventory and costs and war activities engineer, 1942–45; assistant vice-president, engineering, 1945 to date. As engineer of costs and practices he supervised establishment of depreciation charges for a $175,000,000 property and directed development of data on engineering costs that greatly aided field engineering. When he became inventory and costs engineer he retained his responsibilities from his previous position and was also placed in charge of all staff engineering work at the company general office. Next, as engineering and plant operations supervisor, he supervised the engineering of construction for the entire company territory and assumed staff supervision of plant operations. During World War II he added to his responsibilities supervision of war-time protective measures, such as planning special construction projects for the Armed Forces. In his present position he supervised the increase in engineering forces within the organization from 275 to 685. This increase was for handling the large postwar construction program for growth and mechanization with capital expenditures of more than $400,000,000. His activities in the AIEE have included: secretary, Nebraska Section, 1934–35; chairman, Nebraska Section, 1935–36; Secretary, North Central District, 1936–37.

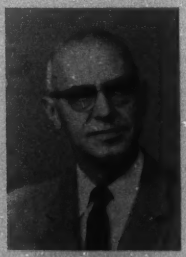


C. W. Minard

A. R. Nelson

Clarence Walter Minard (M '45), assistant general manager, Omaha (Nebr.) Public Power District, has been transferred to the grade of Fellow in AIEE "for contributions to the planning and design of higher voltage distribution systems in extensive rural areas." Mr. Minard was born in Plattekill Township, Ulster County, N. Y., February 14, 1893. He obtained an electrical engineering degree from Syracuse University in 1916. After graduation he entered the student training program at Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. From 1917–18 he was assistant electrical engineer, U. S. Signal Corps, General Supply Depot, Fort Wood, N. Y. From 1918–19 he served with the U.S. Army. After his Army service he joined the Nebraska Power Company, Omaha, predecessor of the Omaha Public Power District. As assistant engineer at Nebraska Power, he did drafting and miscellaneous engineering work. Later he was responsible and prepared detailed plans for the cutover of the underground distribution system in the main business district of Omaha, from 2,300 volts delta to 4 kv Y with multigrounded common neutral. He became assistant to the chief engineer in 1925 assigned to special duties and investigations by the chief engineer. He was appointed assistant chief engineer in 1931. Then he was in charge of all transmission and distribution engineering work under the supervision of the chief engineer. Beginning in 1934 he promoted the development of low-cost farm lines using high-strength conductors, single bushing transformers, and multigrounded common neutral. In this connection he secured the co-operation of the Edison Electric Institute–Bell System Joint Committee on Research and Development in making tests of the inductive influence of 7,620- to 13,200-volt Y multigrounded common neutral rural distribution lines on parallel communication circuits. The tests were made on the Nebraska Power Company system, both in Nebraska and Iowa, during the summer of 1935. They resulted in securing the Bell System approval of the use of such lines and the general adoption by the industry of multigrounded common neutral for rural electrification. He became chief engineer of Nebraska Power in 1937 and in 1946 chief engineer of the Omaha Public Power District, successor to Nebraska Power. He was in full charge of all transmission and distribution engineering work. He was in charge of the design and installation of the secondary network system in the main commercial district in Omaha, which was initially started in 1937. In both 1929 and 1937 he made a detailed allocation of the electric system in the Omaha area, allocating the investment in production, transmission, and distribution facilities to the various classes of service, for rate-making purposes. He supervised the design and construction of the Nebraska section of the 270-mile Omaha-Median 154-kv line and the staged fault tests thereon. This line interconnected the system of the Nebraska Power Company of Omaha with the Kansas Gas and Electric Company system in the vicinity of Wichita. As a part of this project, he coauthored a 1943 AIEE paper, "Staged Fault Tests of Relaying and Stability on Kansas–Nebraska 270-Mile 154-Kv Interconnection." Since 1946 his responsibilities have included drafting and negotiating reserve interchange agreements with the three utilities with which Omaha Public Power District is interconnected. Two of these involved pooling of reserves. In January 1953, he submitted a comprehensive report on the reserve capacity requirements of this group of systems, as well as three subgroups, based on actual outage data for a $6\frac{1}{2}$-year period ending June 30, 1952. As a result of this work, he was made a member of the AIEE Joint Subcommittee on the Application of Probability Methods to Power System Problems.

W. F. Uhl



W. F. Wetmore

Arthur Reynold Nelson (AM '22, M '29), general superintendent of distribution, electric department, Public Service Electric and Gas Company, Newark, N. J., has been transferred to the grade of Fellow in AIEE "in recognition of his engineering and administrative achievement in the over-all guidance of the continued development and expansion of one of the nation's largest transmission and distribution systems." Mr. Nelson was born in Hartford, Conn., June 18, 1897. He received both his bachelor of arts and bachelor of science degrees in electrical engineering from Harvard in 1920. That same year he joined Public Service Electric and Gas Company as a cadet engineer. His career for the past 35 years has included the following positions: cadet engineer, 1920–23; engineer, 1923–24; assistant district superintendent, Camden District, 1924–27; assistant to the division superintendent, Southern Division, 1927–30; assistant division superintendent, Southern Division, 1930–31; assistant transmission and construction engineer, 1931–34; assistant division superintendent, Essex Division, 1934–40; division superintendent, Essex Division, 1940–42; assistant general superintendent of distribution, 1942–49; and general superintendent of

distribution, 1949 to date. The positions listed, all with Public Service in its electric department, show by title his progression through engineering and administrative positions to his present job. This includes complete responsibility for the electric distribution and transmission system of Public Service, in administration and engineering. Within a 3-year period he became assistant district superintendent at Camden. This district then had about 200 employees. The superintendent whom he was assisting was approaching retirement, and he actually served as district superintendent for several years. Then he became assistant to the division superintendent and a short time later assistant division superintendent in the Southern Division. This division was a 1,700-square-mile area which included the cities of Camden and Trenton, N. J. This, perhaps, was the period of his greatest design responsibility. At that time there was a changeover from 2-phase to 3-phase distribution and the development of the 26-kv transmission system in this area. The assistant division superintendent at that time carried most of the engineering responsibilities. He next became assistant transmission construction engineer, responsible for the design, construction, and installation of the 132-kv and 220-kv steel tower lines then being extended very rapidly. Some of the general designs of towers developed during this period are still in use. In 1934 he became assistant division superintendent in the Essex Division, largest of all operating divisions in terms of customers, loads, and employees. He became superintendent of the division and then progressed to the office of the assistant general superintendent of distribution with a state-wide responsibility. He is now responsible for design, installation, and operation of transmission, switching stations, substations, distribution systems, and associated work throughout all Public Service territory. The construction budget of which he has supervision, amounts to $30,000,000 annually. More than $20,000,000 is expended on operation and maintenance under his direction. He has 4,000 employees of whom more than 200 are graduate engineers. These engineers are engaged in many different fields of planning, design, and installation.

William Frank Uhl (AM '12, M '13, Member for Life), president, Charles T. Main, Inc., Boston, Mass., has been transferred to the grade of Fellow in AIEE "for his contributions to the development and design of hydroelectric generating plants." He was born in Sebewaing, Mich., October 14, 1880. He is a graduate of Michigan State College from which he received his bachelor of science degree in mechanical engineering in 1902 and the degree of civil engineer in 1910. He obtained his doctor of engineering degree from Tufts College in 1949. His first employment was with the Platt Iron Works Company, Dayton, Ohio, where he was designer of steam and hydraulic equipment from 1902–04. He then joined the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., as engineer and designer of hydraulic turbines. When he left in 1909 he was acting manager of the hydraulic department. In 1909 he joined the Charles T. Main organization as hydraulic engineer and has been with that organization (now Charles T. Main, Inc.) since. For the past 14 years he has been president. He has been in charge of or associated with the design and construction of about 34 new plants and about 28 redevelopments in important hydroelectric projects. Some of these have been in Africa and Turkey. He has been consulting engineer on 52 other projects. Among these have been: Electric Power, Inc., Shepaug Development, Conn.; Etibank, Sariyar, Turkey; Rockland Light and Power Company, Grahamville Plant, N. Y.; Central Maine Power Company, Indian Pond Development, Maine; Central Hudson Gas and Electric Corporation, Neversink Plant, N.Y.; Clark Hill Development on Savannah River and several other power plants for U. S. Engineers; Central Hudson Gas and Electric Corporation, Eddyville Development, N. Y.; Montana Power Company, several developments; Union Miniere du Haut Katanga, Belgian Congo; Central Hidroelectric Del Rio Anchicaya, Ltd., Colombia, S. A.; Virginia Electric and Power Company, Roanoke Rapids Development, N. C.; consulting and other work on several developments for New England Power Company. In addition to these projects, he is the managing partner of Uhl, Hall and Rich. This is the organization in charge of all engineering for United States interests in the St. Lawrence River Power Development near Massena, N. Y. He is a life member of the American Society of Civil Engineers, a member of The American Society of Mechanical Engineers and the Boston Society of Civil Engineers. He was also the director of the survey for the New England Council report, "Power in New England," published in 1948.

William Frederic Wetmore (AM '36, M'43), director, planning and project engineering department, The Detroit (Mich.) Edison Company, has been transferred to the grade of Fellow in AIEE "for contributions to power system engineering of a large utility and to the development of standards for circuit breakers and rotating machinery." Mr. Wetmore was born December 21, 1895, in Jonesville, Mich. He was graduated from the University of Michigan where he received the bachelor of science degree in electrical engineering. After graduation, in 1920, he joined the General Electric Company's test department, Schenectady, N. Y., as head of turbine test. From 1923–27 he was with the switchgear and central station engineering departments of General Electric. He joined the Detroit Edison Company's Engineering Division in 1928. From 1937–49 he was systems and stations engineer; from 1949–53, chief electrical engineer; and in 1954 director of the planning and project engineering department. The Detroit Edison Company's system has grown from a load of about 500,000 kw to more than 2,000,000 kw during the past 20 years. In this period Mr. Wetmore has had general charge of the design of the system and its transmission and distribution stations and electrical facilities in its power plants. He has had great responsibility in the selection of proper equipment and its application to effect an adequate system of high reliability. As a member of and chairman of the Association of Edison Illuminating Companies' Committee on Electric Switching and Switchgear he has contributed to the development of proper national standards for circuit breakers. Also as a member of the American Standards Association Sectional Committee on Rotating Electrical Machinery and chairman of the Subcommittee on Synchronous Machinery, he has assisted in the development of national standards for all types of a-c and d-c electric machines, with particular emphasis on synchronous generators, induction motors, and exciters. In his work with The Detroit Edison Company, Mr. Wetmore participated in the early development of metal-enclosed segregated phase-switching equipment for use in generating station switchhouses and major system switching centers. The use of metal enclosures was also extended to include generator busses and switchgear for distribution substations of both the indoor and outdoor types. Another early development with which he was associated was the use of tubular and structural shapes for busses and connections for high-current applications. Both copper and aluminum designs were developed for d-c and a-c busses as high as 11,000 amperes. More recently he has directed the engineering and design work involved in the use of some of the industry's largest generating and transformer units. Also, to provide for rapid increases in load density, he has participated in the development of major step-down stations located in heavily settled urban areas. These stations are fed at high voltages by underground cables which tend to replace the older lower voltage system ties. At the present time he is in administrative charge of the planning and project engineering department. The activities of the department include current expansion and long-range system development, power plant and substation design, equipment specifications, and line construction standardization. He is the author of a number of articles which have appeared in the technical press on subjects connected with power system design. He is also author of a section in the "Electrical Engineer's Handbook." Mr. Wetmore served on the Power Generation Committee of AIEE (1944–46, 1950–54) and on the Switchgear Committee (1951–54).

AIEE PERSONALITIES.....

F. O. Prior (M '26), executive vice-president since 1951 and a director for the past 10 years of Standard Oil Company (Indiana), has been elected president of the company. Mr. Prior, a native of Escondido, Calif., attended Stanford University. Although he was in Stanford's engineering class of 1918, he was actually graduated in 1919 after returning from service in World War I. He joined Midwest Refining Company as a laborer in the Salt Creek field. He was promoted to electrical and mechanical engineer. As such, he had direct supervision of designs and construction of the Salt Creek power

plant. In 1925 he was made superintendent of the company's electrical department. In 1928 he was selected as chief engineer and general operating superintendent of Dixie Oil Company, with offices at Shreveport, La. Soon he was elected a director. In 1929 he was elected vice-president in charge of operations, and in 1930 he became president. In December 1930, Stanolind Oil and Gas Company was formed and on January 1, 1931, it took over Dixie and two other producing subsidiaries of Standard. Mr. Prior was made president of the new company, with headquarters in Tulsa. Under Mr. Prior, Stanolind established a comprehensive research program covering exploration, drilling, production, and petrochemical processes. One of its outstanding developments was Hydrafrac, the hydraulic forcing open of tight oil formations to increase their yields. In 1945, Mr. Prior was elected a director and vice-president in charge of production for the parent company. From 1945 until the middle of 1947 he was chairman of the boards of Stanolind Oil and Gas Company, Stanolind Oil Purchasing Company, and Stanolind Pipe Line Company. For one year he was both chairman and president of the pipe-line company. In 1951 Mr. Prior was elected Standard's executive vice-president. He is a member of the American Petroleum Institute, the Transportation Association of America, the Mid-Continent Oil and Gas Association, and the American Institute of Mining and Metallurgical Engineers. Mr. Prior worked on the Institute's General Power Applications Committee (1930–31).

L. L. Fountain (AM '38, F '51), supervising engineer in charge of switchgear applications and a-c network calculators; **W. M. Leeds** (AM '32), manager, circuit breaker development section; **R. E. Friedrich** (AM'45, M'51), design engineer, circuit breaker engineering department; and **J. E. Schramek** (AM '38, M'45), electrical engineer, Westinghouse Electric Corporation, Switchgear Division, East Pittsburgh, Pa., have recently been promoted. Mr. Fountain was named manager, protective-devices engineering department; Dr. Leeds, manager, long-range major development engineering; Mr. Friedrich, manager, circuit-breaker development section; and Mr. Schrameck, manager, compressed-air circuit-breaker engineering section. Mr. Fountain, in his new position, will be responsible for the design and development of various types of circuit breakers and network protectors. He is a graduate of Carnegie Institute of Technology and has been a Westinghouse employee since 1924. He has been credited with 12 patents and is the author of a number of technical papers and articles. He is a native of Washington, D. C., and has served on AIEE's Relays Committee (1947–55). Dr. Leeds will assume responsibility for supervising the special development switchgear engineering projects for commercial use 2–5 years in the future. He received his bachelor's degree in electrical engineering from Haverford College in 1926, his master's degree from the University of Pittsburgh in 1930, and his doctorate from the University of Pittsburgh in 1945. He is the author of 18 AIEE papers, including a national prize paper in 1943. One of Dr. Leeds' 55 patents resulted in a $5,000 award in 1952. In his new position, Mr. Friedrich will head the development of new circuit breakers to meet the expanding requirements of industry. He is a graduate of the University of Pittsburgh with a bachelor's degree in physics and engineering in 1940, and obtained his master's degree from the University of Pittsburgh in 1953. After a short period with Mellon Institute, Mr. Friedrich joined Westinghouse in 1940. He is credited with more than a dozen patents and is the author of several technical papers. He is a native of Mount Washington in Pittsburgh. Mr. Schrameck will direct the design, development, and production of compressed-air circuit breakers. A native of Oklahoma City, he attended grade and high school in Mineral Wells, Tex. He received his bachelor's and master's degrees in electrical engineering at the University of Texas. He joined the Westinghouse Switchgear Division in 1939 and is the author of several technical papers.

G. J. Fiedler (AM '32, M '39), principal engineer, controls and instrumentation section, Sverdrup and Parcel, Inc., consulting engineers, St. Louis, Mo., has been initiated as a professional member of Gamma Theta chapter of Eta Kappa Nu Association, electrical engineering honor society. Mr. Fiedler is a graduate of Kansas State College, 1926, with a bachelor's degree in electrical engineering. In 1934 he obtained the professional degree of electrical engineer from that institution and in 1932 he received the master of science degree in electrical engineering from the University of Kansas. He has also done graduate work toward a doctorate in electrical engineering at the University of Michigan (1941–42). He is a member of Sigma Tau, Phi Kappa Phi, Institute of Radio Engineers, and the Instrument Society of America. He also is a registered professional engineer in New York and Missouri.

T. A. Taylor (AM '30, F '55), chief engineer, The Pacific Telephone and Telegraph Company, San Francisco, Calif., has been appointed assistant general manager of the Northern California and Nevada Area of The Pacific Telephone and Telegraph Company with responsibility for the over-all co-ordination of operating and engineering matters in the area. For biography of Mr. Taylor, see the April issue of *Electrical Engineering*, pages 353–4.

Norton Savage (AM '41), on loan to the Detroit Edison Company from United Engineers and Constructors, Inc., Philadelphia, Pa., for the past 5 years, is now electrical designer in the design engineering department of the Detroit Edison Company. An electrical engineering graduate of the City College of New York, he is a registered engineer in New York and Michigan.

J. L. Hadley (M '42), vice-president and technical counsel, The Peerless Electric Company, Warren, Ohio, has retired. Mr. Hadley graduated from Friends Central Academy in Indiana and received his bachelor's degree in electrical engineering from Purdue University in 1912. Before and during his attendance at Purdue he worked as a lineman and house-wireman for a utility company. After graduation he was with Fairbanks Morse and Company for 2 years and with the Remy Electric Company for 2 years. During the 39 years with the Peerless Electric Company he served as electrical engineer, chief engineer, factory manager, member of the board of directors, and vice-president. He was responsible for many developments in the field of special application motors and generators. He is a registered professional engineer in the State of Ohio.

Donald Berges (M'50), works manager Master Electric Company, Dayton, Ohio, has been advanced to vice-president in charge of manufacturing. Mr. Berges graduated from Stevens Institute of Technology in 1931 with a degree in mechanical engineering. After graduation, he joined the Eclipse Aviation Division of Bendix Aviation Corporation in Teterboro, N. J. He became chief field engineer there in 1939 with complete responsibility for all outside sales engineering contacts between Eclipse and all domestic air-frame manufacturers. In 1943 he became chief engineer of the Electrical Division of Borg Warner Corporation's Pesco Products Division. He organized personnel, supervised design of a complete line of high-performance d-c motors. He also specified equipment needed for a $60,000 motor development laboratory and developed training methods and test procedures to permit using help unfamiliar with motors in the motor development program. In 1950 he was appointed chief engineer of the new Pesco Products plant in Bedford, Ohio, in charge of research facilities.

J. T. Persons (M '45, F '51), retired chief engineer of Central Power and Light Company, Corpus Christi, Tex., has been named "Engineer of the Year" by the Nueces Chapter of the Texas Society of Professional Engineers. He was presented the honor at a special Engineers Week banquet. A graduate of the University of Texas, Mr. Persons has spent 44 years in the electrical industry. Following his graduation from college, he worked for the General Electric Company, Des Moines Electric Company, and Texas Power and Light Company before joining Central Power and Light. He was chief engineer for Central Power for 25 years. Mr. Persons was also a vice-president and a member of the company's board of directors. He retired from active service in 1953.

R. C. Waldron (M '38), assistant chief engineer, The Okonite Company, Passaic, N. J., has been appointed manager of engineering of the company and will supervise the activities of the engineering department. **E. E. McIlveen** (AM '44) has become assistant manager of engineering. Mr. Waldron was named senior engineer in 1954, prior to which time he was assistant to the chief engineer. He has been associated with The Okonite Company since 1928 and has been engaged in the development and application of all types of electric cables. He received his electrical engineering degree, cum laude, in 1928 from Harvard University. He is a member of Tau Beta Pi and

is presently serving on AIEE's Committee on Industrial Power Systems. He is also a member of the AIEE Insulated Conductors Committee and has served on the Industrial Power Systems Committee (1950–55). Mr. McIlveen, previously cable engineer, joined The Okonite Company in 1941, before which time he had been associated with the Ocean Cable Engineers' Office of the Western Union Telegraph Company. He has been engaged in research and development work and in 1954 joined the engineering department of Okonite. A graduate of Polytechnic Institute of Brooklyn in 1943, Mr. McIlveen received a degree, cum laude, in mechanical engineering. He is a member of Sigma Xi, The American Society of Mechanical Engineers, and of the Montclair Society of Engineers. He also serves as a member of AIEE's Insulated Conductor Committee.

J. G. Everhart (AM '39, F '51), chief engineer, Line Material Company's Transformer Division, Zanesville, Ohio, has been named plant manager of the company's fibre products plant in Sherman, Tex. **R. P. Thompson** (AM '42, M '51), assistant chief transformer engineer at Zanesville, is now chief engineer. Mr. Everhart joined Line Material in 1938 as an inspector at the Zanesville plant. He served as assistant chief inspector, assistant to the chief draftsman, cost engineer, development engineer, assistant chief engineer, and in 1948 chief engineer of the Transformer Division. He earned his electrical engineering degree from Pennsylvania State University. He is a registered professional engineer in Ohio, a member of the American Management Association, and the American Institute of Management. He is also a member of Eta Kappa Nu, Tau Beta Pi, and Sigma Tau, honorary engineering societies. Mr. Thompson joined Line Material in 1941 as a member of the inspection department. He was later transferred to the electrical design section and was promoted to chief electrical design engineer in 1945 and served in that capacity until 1949. In 1940, he was graduated from Ohio State University with an electrical engineering degree. He is a registered professional engineer in Ohio.

H. L. Peek (AM '37, M '46), development design engineer, development engineering group, Boston (Mass.) Works, Allis-Chalmers Manufacturing Company, has been promoted to engineer-in-charge of the development group. Mr. Peek joined Allis-Chalmers in 1946.

D. B. Kendall, Sr. (AM '52), senior electrical engineer, Toledo (Ohio) Scale Company, has been appointed manager of the development engineering department at Toledo Scale. He is now responsible for all design, development, field testing, and production activities of the Engineering Division. Mr. Kendall has been with the Engineering Division since 1933.

W. E. Doughty, Jr. (AM '41, M '54), assistant general plant supervisor, plant department, Home Telephone and Telegraph Company, Fort Wayne, Ind., has been promoted to equipment engineer. He is responsible for all radio and electronic equipment used by the company. He was born in Detroit, Mich., 1916, and has a bachelor of science degree in electrical and radio engineering from Tri-State College. He joined Home Telephone and Telegraph Company after graduation from college. During World War II he served with the U. S. Navy. Besides the AIEE, he is a member of the Fort Wayne Engineers' Club.

R. W. Hutchinson (AM '42), Eastern Division manager, Pacific Electric Manufacturing Corporation, Chicago, Ill., has been appointed product sales manager for the company's Pacific Switchgear Division. Mr. Hutchinson will supervise the promotion and execution of the division's sales policies. His offices will be at San Francisco, Calif., where Federal Pacific maintains its Western headquarters. Mr. Hutchinson has been a member of the Federal Pacific organization for a number of years; since 1946 with Pacific Electric Manufacturing Corporation, and subsequently, when Pacific was acquired by Federal Electric Products Company in 1953, with the merged company. Before joining Pacific, he was a sales engineer with Westinghouse. Following his graduation from the University of Washington, where he received a bachelor of science degree cum laude in electrical engineering, Mr. Hutchinson studied for 2 years with the Westinghouse graduate student training course. During World War II he spent 6 years in the U. S. Navy. He is a member of Tau Beta Pi honorary fraternity.

R. H. Olson (AM '52), co-ordinator of National Bureau of Standards missile fuse projects and project leader for special military development tasks, Motorola, Inc., has been appointed director of engineering in the Communications and Electronics Division of Motorola. In this capacity he will direct the technical activity of the division's industrial products department. He is now in charge of engineering co-ordination for industrial products and nonmilitary research and development efforts. Mr. Olson has been with Motorola since 1951, when he joined the company's Phoenix Research Laboratory as an engineering section leader. A native of Mitchell County, Iowa, he received his electrical engineering degree from Iowa State College in 1934 and immediately began a 13-year association with Collins Radio Company. Later he operated his own manufacturing and consulting firm before joining Motorola. His most recent work has been with subminiature missile electronic fuses.

L. A. Finzi (AM '40, M '49), professor of electrical engineering, Carnegie Institute of Technology, Pittsburgh, Pa., has been named to succeed **B. R. Teare, Jr.**, (AM '29, F '42), dean of engineering and science, as Buhl professor. The professorial chair was established in 1943 by the Buhl Foundation as a development of the graduate program in electrical engineering which the foundation established in 1939. The Buhl program was inaugurated to answer a need in modern technology, the combination engineer-scientist. Dr. Teare, who came from Yale University to inaugurate and direct the new graduate program, became first incumbent of the Buhl chair. In 1944, he became head of the department of electrical engineering. He was appointed dean of graduate studies in 1950 and in 1953, he became dean of the college of engineering and science. The weight of these responsibilities has caused him to relinquish the Buhl professorship. The new Buhl professor, Dr. L. A. Finzi, was born in Italy. He received his doctorate from the Institute of Technology of Aachan, Germany, in 1932. In 1938 he became head of the electrical impulse laboratory at the Westinghouse East Pittsburgh plant. In 1946 he joined the Carnegie Institute of Technology's faculty. He was recipient of one of this year's teaching awards at Carnegie. As Buhl professor he will work to develop research leadership in the graduate electrical engineering program. Dr. Finzi served on the Basic Sciences (1949–53) and Magnetic Amplifiers Committees (1951–55). Mr. Teare served on the following committees: Communication (1934–36), Electrical Machinery (1937–42), Education (1941–55, chairman 1948–50), Professional Group, Co-ordinating Committee (1948–49), Technical Program (1948–50), Publication (1948–50), Edison Medal (1951–56).

C. H. Black (AM '41, M '45) general manager of General Electric Company's meter and instrument department, has been appointed general manager of the Construction Materials Division. Mr. Black, a native of Baltimore, Md., joined General Electric in Schenectady in 1924 as a student engineer on the test program. He was graduated that year from Johns Hopkins University with a bachelor's degree in electrical engineering. Following various assignments in the switchgear department, he was transferred to Philadelphia where he served as an application engineer on switchgear equipment. In 1942 he was transferred to the company's Trenton, N. J., switchgear plant. He returned to Philadelphia in 1944 and in 1948 was named manager of engineering for the Construction Materials Division at Bridgeport, Conn. In October, 1951, he was named general manager of the meter and instrument department at Lynn, Mass., his most recent position. He has served on AIEE's Protective Devices Committee (1944–45) and the Switchgear Committee (1947–48).

M. P. Getting, Jr. (AM '37, M '49), assistant to the works manager at Allis-Chalmers Pittsburgh (Pa.) Works, has been appointed assistant to the general manager. Getting's successor is **George Shombert, Jr.** (AM '39, M '48), assistant superintendent of the electrical test department since 1949. Mr. Getting joined Allis-Chalmers in 1927 as an undergraduate apprentice while attending the University of Pittsburgh where he received his electrical engineering degree. He advanced from a tester to inspector, superintendent of the test department, and assistant to the works manager. He has been active in AIEE, the American Society for Testing Materials, and the American Industrial Radium and X-Ray Society. Mr. Shombert joined Allis-Chalmers in 1937 as a test department helper. He is an

electrical engineering graduate of Carnegie Institute of Technology. His affiliations have included AIEE and the American Society for Metals. He has served AIEE's Public Relations Committee (1947–50).

E. S. Sherrard (AM '50), project engineer, aircraft electrical systems research, Naval Research Laboratory, Washington, D. C., has joined the staff of the National Bureau of Standards, where he will conduct research on analogue computing systems for the simulation of jet engines and jet engine control systems. From 1944 to 1951, Mr. Sherrard was with General Electric Company as an application and development engineer in the fields of servomechanisms, electric machinery, and aircraft electric systems. He was born in New Orleans, La., in 1922. He obtained his degree in electrical engineering from Tulane University.

OBITUARIES • • • •

Stetfan Tanabe (M'50), Local Honorary Secretary for AIEE in Japan, died April 11. He was consultant for the Tokyo-Shibaura Electric Company, Ltd., in Tokyo. Mr. Tanabe was very conscientious as Honorary Secretary, handling AIEE membership applications for his country. As long ago as 1929 he was taking active part in Institute affairs and attended the World Engineering Congress in Tokyo that year. He joined AIEE in 1915 as an Associate Member and became a full Member in 1927. During World War II he found it impossible to continue his membership, but in 1950 rejoined. When he originally joined, he was working at the General Electric Company's Standardizing Laboratory in Schenectady, N. Y., as a research and experimental engineer in magnetics. (This Laboratory became the General Engineering Laboratory.) He attended the University of Illinois to obtain a degree and then returned to the General Electric Company. He then joined the Tokyo Electric Company, Kawasaki, Japan, as meter design engineer. For a short time he was at General Electric's Lynn Works as engineer-representative of the Tokyo Electric Company under a meter contract. He was also chief of an experimental testing room for electric instruments and electric precision appliances in the Engineering Division of this company which later became the Tokyo-Shibaura Electric Company. From 1936–41 he was a member of the board of directors of Special Alloy Company, Ltd. From 1943–46 he was first chief of the Engineering Division and then acting director controlling all important electrical materials. In December of 1945 he became manager and later consultant of the Production Division of Saito Industrial Company, manufacturers of electrical materials. In 1947 he was appointed consultant to the Yokohama Chamber of Commerce and Industry, as well as its branch, the Yokohama Foreign Trade Institute, dealing with machines and apparatus for exporting. Prior to World War II he had been a member of the Physical Society.

Warren B. Sanford (AM'04, M'30, Member for Life), retired plant manager, Bell Telephone Laboratories, Inc., died April 27. Mr. Sanford had retired from Bell Laboratories in 1935 after more than 31 years of active service. He was born in North Adams, Mass., September 22, 1878, and attended North Adams' public schools. He graduated from Cornell University in June 1901 and was elected to Sigma Xi. After graduation from Cornell, he joined the Western Electric Company's factory engineering department. From 1903–05 he was with the United Telpherage Company until it was absorbed by Dodge Coal Storage Company. In 1905 he rejoined Western Electric which was later separated as Bell Telephone Laboratories. He was appointed factory engineer in 1909, in charge of plant operation and construction. In 1913 he was given supervision of the shop departments and was transferred to the general purchasing department in 1915. During World War I he superintended the manufacture of vacuum tubes for government use, and after that superintended practically all physical alterations in the laboratories' building. In 1935 he was pensioned at his own request. His other society affiliations included: American Society of Mechanical Engineers, New York Electrical Society, and the Telephone Pioneers of America.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of May 19, 1955, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Applegate, J. A., asst. process engineer, Silas Mason Co., Burlington, Iowa
Armstrong, T. W., Jr., research engineer, Boeing Airplane Co., Seattle, Wash.
Bean, J. W., relay & control engineer, American Gas & Electric Service Corp., New York, N. Y.
Biele, R. J., manager-engineering, General Electric Co., Syracuse, N.Y.
Blackston, L. B., supervisor, distribution planning dept., Houston Lighting & Power Co., Houston, Tex.
Blaiklock, W. J., sales engineer, General Electric Co., New Haven, Conn.
Blankenbeker, E. L., electrical engineer, Heyl & Patterson, Inc., Pittsburgh, Pa.
Botts, J. C., insulation development engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Bovenizer, W. N., design engineer, Line Material Co., Zanesville, Ohio
Brands, W. H., engineer, Philadelphia Electric Co., Philadelphia, Pa.
Carp, G., executive manager, Carp Development Laboratory, South Norwalk, Conn.
Dalasta, D., general engineer, switchgear dept., Allis-Chalmers Mfg. Co., West Allis, Wis.
Davis, J. W., outside plant engineer, Southern Bell Tel. & Tel. Co., Atlanta, Ga.
DeInza, C., assistant chief engineer, RENFE, Madrid, Spain
Deuring, W. G., Jr., design & development engineer, General Electric Co., Pittsfield, Mass.
Dodson, G. C., Jr., supervisor engineering laboratory, General Electric Co., Schenectady, N.Y.
Erlebach, G. B., electrical engineer, Cemco Electrical Manufacturing Co., Ltd., Vancouver, B.C., Canada
Frost, S. C., Jr., engineer, Southwestern Bell Telephone Co., Dallas, Tex.
Gohry, H. A., district engineer, Southwestern Bell Telephone Co., Dallas, Tex.
Gordon, K. E., assistant engineer, New England Power Service Co., Lawrence, Mass.
Henning, R. A., senior group engineer, Boeing Airplane Co., Seattle, Wash.
Henry, E. N., engineering section manager, Westinghouse Electric Corp., Sharon, Pa.
Hidy, J. W., equipment engineer, Mountain States Tel. & Tel. Co., Denver, Colo.
Hodgman, N. G., assistant vice-president, New England Power Co., Boston, Mass.
Husbands, L. D., field service electrical engineer, Westinghouse Electric Corp., Charlotte, N.C.
Jamison, G. B., regional manager, Crouse-Hinds Co., Houston, Tex.
Kelly, R. E., senior engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Kunes, J. J., design engineer, Westinghouse Electric Corp., Sharon, Pa.
Lamb, F. J., field planning engineer, Detroit Edison Co., Detroit, Mich.
Laton, B. C., electrical engineer, U. S. Bureau of Reclamation, Sacramento, Calif.
Leahy, J. J., Jr., electrical engineer, Chas. T. Main, Inc., Boston, Mass.
Leh, M. C., Jr., utilities engineer, Safeway Stores, Inc., San Francisco, Calif.
Leland, R. W., staff engineer, Delco Products Div., General Motors Corp., Dayton, Ohio
Levitsky, F. J., asst. engineer, central laboratory, New England Power Service Co., Worcester, Mass.
Lichstein, M., supervisor, United Engineers & Constructors, Inc., Philadelphia, Pa.
Litrides, S. J., project engineer, Pennsylvania Power & Light Co., Allentown, Pa.
Lunn, E. O., consulting engineer, Vancouver, B.C., Canada
Lynch, E. D., Jr., application engineer, Westinghouse Electric Corp., Hartford, Conn.
Mack, D. R., supervisor, electric machine projects, turbine laboratory, General Electric Co., Schenectady, N.Y.
Maddock, R. B., product planning & marketing research specialist, General Electric Co., Schenectady, N.Y.
Mann, C., district engineer & service manager, Westinghouse Electric Corp., Cleveland, Ohio
McCahan, A. J., asst. head, testing & standards section, Boston Edison Co., Boston, Mass.
McKee, H. W., supervisory electrical engineer, U.S. Naval Ordnance Laboratory, Silver Spring, Md.
Messer, G. E., manager, Apparatus Sales Div., General Electric Co., Kansas City, Mo.
Moore, R. K., electrical engineer, The Scranton Electric Co., Scranton, Pa.
Morgan, K. H., engineer, Southern Bell Tel. & Tel. Co., Bogalusa, La.
Morrison, A. C., superintendent, meter dept., Duke Power Co., Charlotte, N.C.
Morton, R. K., electrical engineer associate, Water & Power Dept., City of Los Angeles, Calif.
Murrish, C. H., asst. professor of electrical engineering, Clarkson College of Technology, Potsdam, N.Y.
Myers, D. K., electrical engineer, F. R. Martin, consulting engineers, St. Louis, Mo.
Nayar, G. G. P., general manager, The Aluminum Industries, Ltd., Kundara, Travancore, India
Noodleman, S., manager, Electric Division, Standard Dayton Corp., Dayton, Ohio
Oliver, W. H., division plant supervisor, long lines dept., American Tel. & Tel. Co., St. Louis, Mo.
Phelps, H. B., engineer, Niagara Mohawk Power Corp., Albany, N.Y.
Price, M. K., development engineer, Eastern Power Devices, Toronto, Ont., Canada
Robertson, T. O., senior design engineer, Boeing Airplane Co., Seattle, Wash.
Ryan, W. J., senior electrical engineer, Kelso Burnett Electric Co. & Associates, Louisville, Ky.
Spencer, J. H., manager-laboratory, meter dept., General Electric Co., Somersworth, N.H.
Stawicki, S. W., supt., Fluorescent Division, Champion Lamp Works, Lynn, Mass.
Storaasli, B. A., electrical engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Tamis, G. A., senior product engineer, Champion Lamp Works, Lynn, Mass.
Terry, W. M., Jr., asst. chief engineer, Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Throop, G. D., design engineer, Westinghouse Electric Corp., Sharon, Pa.
Tuttle, P. D., research engineer, Aluminum Co. of America, Massena, N.Y.
West, H. J., generating station engineer, Pennsylvania Power & Light Co., Allentown, Pa.
Zahour, R. L., manager, illuminating engineering section, Westinghouse Electric Corp., Bloomfield, N. J.

66 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before July 25, 1955, or September 25, 1955, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Bird, J. F., A. Reyrolle & Co. Ltd., Salisbury, Southern Rhodesia, Africa
Donworth, R. B., Duquesne Light Co., Pittsburgh, Pa.
Fairchild, F. P., Public Service Electric & Gas Co., Newark, N. J.
Konstantinowsky, K., Standard Telephones & Cables Ltd., London, England
Marlowe, D. E., U. S. Naval Ordnance Laboratory, Silver Spring, Md.
Speirs, R., Dorman & Smith Ltd., London, England

6 to grade of Member

OF CURRENT INTEREST

New G-E Dual-Cycle Boiling Reactor Will Power Largest All-Nuclear Station

DESIGN of a new atomic power reactor, described as a "major advance toward the economic generation of electricity from atomic energy," was announced recently by Francis K. McCune, General Electric Company vice-president and general manager of the company's Atomic Products Division.

Mr. McCune said that one of these new dual-cycle boiling reactors will power the proposed full-scale nuclear electric generating station that the company will construct, subject to Atomic Energy Commission approval of the project, for the Commonwealth Edison Company near Chicago, Ill.

Plans for the plant set the generating capacity at 180,000 kw, the largest all-nuclear station yet scheduled. The plant will be located on a 750-acre site near the confluence of the Kankakee and Des Plaines rivers in Grundy County, Ill., and will be owned and operated by the Commonwealth Edison Company.

The new power reactor design will be able to produce several times as much power in a given size as its predecessor, the direct boiling reactor. The General Electric dual-cycle boiling reactor is a type expected to achieve competitive generating costs with ordinary steam power plants in succeeding models.

The reactor was described as capable of being used without heat exchangers by generating steam directly inside the reactor core, thus eliminating the need for high operating pressures and temperatures used in liquid-water-cooled power reactors.

The proposed Illinois station will be sponsored by the Nuclear Power Group, Inc., and will be financed completely with private funds. Sponsoring companies are: American Gas and Electric Service Corporation, Bechtel Corporation, Commonwealth Edison Company, Pacific Gas and Electric Company, Union Electric Company of Missouri, Central Illinois Light Company, Illinois Power Company.

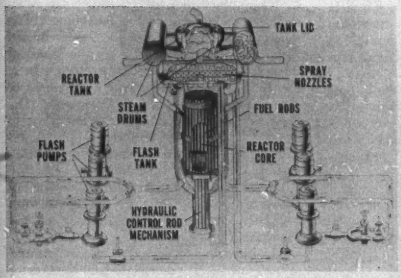
The original concept of the direct-boiling reactor, pioneered at the Atomic Energy Commission's Argonne National Laboratory by Dr. W. H. Zinn and associates, was adapted by General Electric for use in a large power station. In doing so, ways have been found to multiply the output of such reactors, permitting their application to large power plants on a commercial scale.

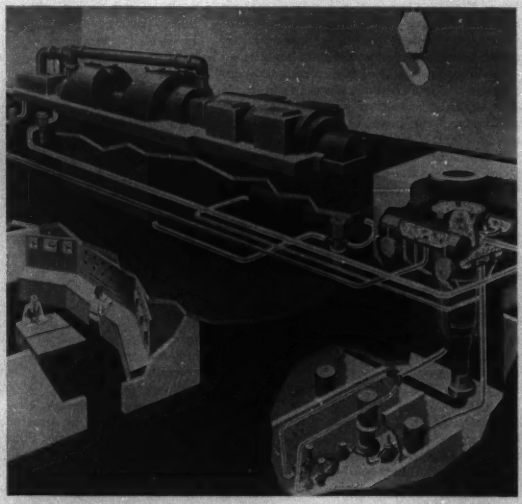
The inherent safety of the direct boiling reactor has been retained in the dual-cycle design, and at the same time stability with relation to load has been vastly improved. When increased load demands are made on the direct-boiling reactor, output tends to be reduced just at that point when power is needed most.

General Electric engineers introduced a "flash tank" system into the new reactor which controls steam formation by feeding cooler water into the entrance of the reactor as load demands increase. This maintains the delicate balance of the chain reaction in such a way that the reactor automatically delivers more power to supply the load increase. The dual-cycle reactor in effect, accommodates itself to the demands of the power system without requiring changes in reactor controls. Steam is provided to the turbine at two pressures; for example, 600 pounds per square inch from the reactor vessel for the first turbine stages, and 350 pounds from the "flash tanks" for immediate stages.

In contrast, nonboiling reactors cooled by high-temperature high-pressure water would have to operate under a pressure of approximately 2,000 pounds in order to generate steam at 500 pounds for use in the turbine.

The dual-cycle reactor also has the following advantages: (1) primary loop pressure essentially the same as turbine pressure; (2) good thermal efficiency for a given reactor temperature; (3) exceptionally high degree of inherent safety due to boiling in the reactor; (4) flexibility of operation to meet power demand changes without delay; (5) self-stabilizing power level to match load variations.





DUAL-CYCLE BOILING REACTOR details are shown in the drawing above. Water circulates up from bottom of main pressure vessel through reactor core and is converted into steam. Flash tank furnishes additional steam to turbine-generator and water at temperatures well below boiling to reactor. At right is an artist's conception of how the 180,000-kw dual-cycle reactor might look when coupled to a turbine-generator for production of power for home and industries. Water is boiled directly inside atomic reactor, right of picture, to produce steam that drives turbine-generator at upper left. Control panel for dual-cycle reactor is at lower left of the illustration. The new reactor will be used to power a proposed nuclear electric generating station.

The 60-inch searchlight used to control air traffic at LaGuardia Airport

Sky Highway "Traffic Light" Utilizes One of World's Brightest Searchlights

A SKYWAY "TRAFFIC LIGHT" that directs departing planes over a more sparsely settled take-off route has been installed near busy La Guardia Airport in Queens, N.Y., in an effort to minimize the noise near heavily populated areas. Operated by the Civil Aeronautics Administration, the beacon is sent skyward by one of the most powerful searchlights ever built. A 2,500-watt short-arc mercury lamp developed by the Westinghouse Electric Corporation produces a shaft of light of some 300-million-beam candle-power, equivalent in light intensity to approximately 10,000 automobile headlights.

An unusual aspect of the aerial beacon is that pilots do not actually see the light itself, but instead depend on the high-intensity light flux of the beam to be reflected from moisture and dust particles in the air. The visible column rises skyward approximately 3 miles beyond the end of the runway and is tilted toward the airport at about 30 degrees from a vertical position. As planes take off, they fly directly toward the beam and are led down Flushing Meadow away from the residential areas on either side, greatly reducing the noise nuisance.

The light was purchased and installed by the National Air Transport Co-ordinating Committee (NATCC). Headed by Captain E. V. Rickenbacker, the NATCC is conducting a voluntary aircraft noise-abatement program in the vicinity of the major New York–New Jersey air terminals. Vice-Admiral C. E. Rosendahl, U. S. Navy (retired), NATCC executive director, said the plan for using the beacon as a noise-abatement aid was developed by the NATCC technical committee, comprised of the Civil Aeronautics Administration, the Air Line Pilots Association, The Port of New York Authority, and Air Transport Association representatives.

This type of mercury lamp, originally developed for Navy searchlights, does a good job because of its high intensity and the fact that it can be operated unattended. The mercury arc, burning between tungsten electrodes spaced only 3/8 inch apart, is a clean flame, and the lamp is completely enclosed and hermetically sealed in a quartz bulb. Remote control operation from the La Guardia control tower makes it possible to light the beacon only when the runway is in use at night.

The searchlight itself is a 60-inch unit formerly used by the Army in connection with antiaircraft gun emplacements. Removed from its wheels, it is mounted on a permanent concrete foundation and surrounded by a high wire fence.

Sloan Foundation Sets Up Fund to Aid Basic Scientific Research

The Alfred P. Sloan Foundation, Inc., announced recently the setting up of a specific fund of $5,000,000, both the principal and income of which are to be devoted to promoting basic research in the physical sciences, that is, biology, chemistry, electronics, nuclear energy, etc.

The fund will be provided by a special gift to be made to the Foundation by Mr. and Mrs. Alfred P. Sloan, Jr., for this specific purpose.

The trustees of the Foundation are convinced that great need exists to expand activities in the area of basic research, especially in the physical sciences. They feel there are great oportunities for such fundamental research. They have come to this conclusion as the result of a year's study made by five eminent scientists headed by Dr. Roger Adams, research professor of chemistry at the University of Illinois.

There appears to be a unanimity of opinion among scientists that, as a country, we are lagging behind in basic research and present efforts are insufficient adequately to support applied research, technological advance, and engineering progress so essential to an expanding economy.

It also seems to be generally conceded that, notwithstanding the great scientific accomplishments of the United States, far too great a proportion of basic research in the past has emanated from foreign sources. We have been remarkable exploiters but not particularly good discoverers.

The trustees of the Foundation recognize that while government funds are being provided on a large scale—although in relatively small measure for basic research—the very existence of such funds will enhance the opportunity for funds from private sources. Such funds will serve as a catalyst in elevating standards of performance, in providing flexibility for research programs, and in giving an opportunity to investigators who may be without adequate resources to seek out unusual talent and neglected opportunities. These observations apply particularly to physical science.

To effectuate its research program, the Foundation has set up a program committee of five scientists actively engaged in basic research in the physical sciences. The method will be: first to discover areas of science in which there are extraordinary needs and an opportunity for fundamental advance; second, to locate talented scientists who can be expected to undertake such investigations effectively and who have a deep urge to do so; third, to set up optimum conditions for their work.

The committee is headed by Dr. Arthur C. Cope, professor of chemistry at Massachusetts Institute of Technology. Its four other members are: Dr. James Brown Fisk, director of research in the physical sciences, Bell Telephone Laboratories, Inc.; Dr. K. S. Pitzer, head of the department of chemistry, University of California; Dr. Frederick Seitz, head of the department of physics, University of Illinois; and Dr. A. W. Tucker, head of the department of mathematics, Princeton University.

Dr. Richard T. Arnold, professor of chemistry at the University of Minnesota, has been appointed administrator of the program.

The individuals selected as researchers and investigators will be associated, for the greater part, with American universities and technological institutions.

One plan will be to relieve them, in whole or in part, from their academic duties for a period of time so that they may devote their talents and ambitions to such areas of basic research in the physical science as seem to offer the greatest promise.

Another plan of support to be followed under the program will be to supply these investigators with funds which will make it possible for them to appoint predoctoral or postdoctoral fellows to participate in basic

research with the senior investigator, and also to cover the cost of any special services or equipment for effective research.

The four scientists who joined with Dr. Adams in the study which led to the decision to undertake the research program were: Dr. Mervin J. Kelly, president of Bell Telephone Laboratories, Inc.; Dr. W. Albert Noyes, Jr., head of the department of chemistry, University of Rochester; Dr. J. A. Stratton, provost and vice-president of Massachusetts Institute of Technology; and Dr. Robert W. King, formerly assistant to the president, Bell Telephone Laboratories.

Low-Frequency Vibrations of the Heart Can Be Detected With Supersensitive Pickup

FAINT SOUNDS of the heart, which neither the human ear nor a physician's stethoscope can hear, now can be seen with a new device developed co-operatively by the Medical College of South Carolina and General Motors Research Laboratories Division. These low-frequency vibrations, below the range of human hearing, are detected by an Electro Stethograph. Medically they are reported to be of "potential clinical significance."

Dale Groom, M. D., assistant professor of medicine at the Medical College of South Carolina, proposed the idea for the new device. He was aided by Charles F. Kettering, General Motors research consultant, who suggested that part of a General Motors Research-developed instrument, the Surfagage, might be adaptable to the medical job. The Surfagage is used in machine shops, manufacturing, and assembly plants to measure roughness of such highly machined auto parts as gear teeth, clutch facings, crankshafts, bearings, and cylinder bores.

The Stethograph was developed by mating part of a stethoscope, the medical profession's traditional listening device for heart and chest sounds, with the supersensitive pickup of the Surfagage. In essence, this combination gives physicians a high-fidelity record of the heart's sounds and vibrations. Its sensitivity can be compared with that of a seismograph.

Dr. Groom and John A. Boone, M. D., professor of medicine at the Medical College of South Carolina, now can see the heart's inaudible sounds either with an oscilloscope or a direct-writing device that records wavy lines with pen and ink.

With the engineering job of detecting these new "sounds" accomplished, medical researchers believe the low-frequency tracings or patterns will offer new clues to the heart's behavior.

ELECTRO STETHOGRAPH, a device developed co-operatively by Dr. Dale Groom (center), Medical College of South Carolina, and General Motors Research Laboratories, can detect some of the heart's inaudible sounds. A sensitive pickup on a patient's chest picks up these low-frequency sounds so they can be recorded on a direct-writing device which J. B. Bidwell, General Motors, is checking at the right.

They may indicate whether a heart functions normally or is affected by some disease or defect. The problem now is to accumulate clinical data to compare or contrast with known patterns of normal heart action.

A patient undergoing examination merely lies on a foam rubber mattress, which absorbs any interference vibrations. The Stethograph pickup, approximately the diameter of a silver dollar with a small arm attached, is placed on the patient's chest and the heart vibrations are observed or recorded.

The principles by which the Stethograph and Surfagage operate are similar. The Surfagage detects scratches as small as one millionth of an inch on surfaces of highly machined automotive parts. Its pickup consists of a tiny diamond stylus linked with a high-sensitivity transducer that transforms motion into electric signals. When the stylus is moved over unseen "peaks and valleys" on a machined metal surface, its microscopic up-and-down motion is transformed into electric signals. The diaphragm head of a stethoscope was attached to the Surfagage pickup.

The human ear can hear sounds ranging anywhere from 39 to 15,000 cycles per second. Its efficiency, however, is relatively poor in the lower part of the range. The Stethograph's hearing range is as low as 1 cycle per second. Vibrations of that order are produced by the heart's pumping action as imparted to the chest wall. In a recent report Drs. Groom and Boone said these inaudible sounds represent the greater portion of the heart's vibrational energy, greater than the portion a physician ordinarily hears by ear through his stethoscope.

The doctors already have found the Electro Stethograph pickup so selective that its "hearing" is localized. For instance, as the pickup is shifted to various zones over a patient's heart, remarkable differences appear in the recorded waves. The doctors visualize this new device as a supplement to other instruments for charting heart action—the electrocardiograph and the phonocardiograph.

One of the advantages of the Stethograph is that it is comparatively simple to operate and manufacture. It can be made available readily to clinics and hospitals and is adapted for use with conventional recording equipment now used by physicians to study heart function.

Summer Transistor Symposium Offered at University of Michigan

During the month of July a 4-week transistor application symposium will be offered at Ann Arbor, Mich., by the electrical engineering department of the University of Michigan in co-operation with the Bell Telephone Laboratories. This will be operated as a part of the regular summer session of the University of Michigan, and course credit may be obtained, either in the Graduate School or the College of Engineering, by students qualified by previous training in electric circuit analysis. Professor W. G. Dow of the department of electrical engineering is symposium director.

Lectures will treat various aspects of

Future Meetings of Other Societies

National Skilled Manpower Training Conference, sponsored by the Virginia Apprenticeship Council with the assistance of the U. S. Department of Labor's Bureau of Apprenticeship. July 5–8, 1955, Chamberlin Hotel, Old Point Comfort, Va.

Symposium on Electronics and Automatic Production, jointly sponsored by Stanford Research Institute and the National Industrial Conference Board. August 22–23, 1955, San Francisco, Calif.

Western Electronic Show and Convention. August 24–26, 1955, Civic Auditorium, San Francisco, Calif.

Instrument Society of America, Conference, "Instrumentation Paces Automation." September 12–16, 1955, Shrine Auditorium, Los Angeles, Calif.

Illuminating Engineering Society, National Technical Conference. September 12–16, 1955, Statler Hotel, Cleveland, Ohio

Association for Computing Machinery, Annual Meeting. September 14–16, 1955, University of Pennsylvania, Philadelphia, Pa.

Radio-Electronics-Television Manufacturers Association, Automation Symposium. September 26–27, 1955, Irvine Auditorium, University of Pennsylvania, Philadelphia, Pa.

Atomic Industrial Forum, Trade Fair and Fall Meeting. September 26–30, 1955, Sheraton-Park Hotel, Washington, D. C.

Société Belge des Ingenieurs des Telecommunications et d'Électronique, International Analogy Computation Meeting. September 27–October 1, 1955, Brussels, Belgium

National Electronics Conference, Inc. October 3–5, 1955, Hotel Sherman, Chicago, Ill.

Canadian Electrical Manufacturers Association, 11th Annual Meeting. October 5–7, 1955, Sheraton-Brock Hotel, Niagara Falls, Ont., Canada

Electrochemical Society, Inc. October 9–13, 1955, William Penn Hotel, Pittsburgh, Pa.

National Safety Council, 43d National Safety Congress and Exposition. October 17–21, 1955, Conrad-Hilton Hotel, Chicago, Ill.

Steel Founders' Society of America, Fall Meeting. October 24–25, 1955, The Greenbrier, White Sulphur Springs, W. Va.

American Standards Association, 37th Annual Meeting in conjunction with 6th National Conference on Standards sponsored jointly by ASA and the National Bureau of Standards. October 24–26, 1955, Sheraton Park Hotel, Washington, D. C.

Pennsylvania Electric Association, Fall Meeting of Electrical Equipment Committee. October 27–28, 1955, Hotel New Yorker, New York, N. Y.

National Conference on Industrial Hydraulics, 11th Annual Meeting. October 27–28, 1955, LaSalle Hotel, Chicago, Ill.

Institute of Radio Engineers, East Coast Conference on Aeronautical and Navigational Electronics. October 31–November 1, 1955, Lord Baltimore Hotel, Baltimore, Md.

transistor circuit applications, with "problem laboratory" sessions paralleling the lecture presentations. In these sessions the lecture material will be worked into illustrative engineering problems.

The general instructional objective of the symposium is to provide an opportunity for indoctrination in and illustrative employment of transistor circuit application principles. The program should be of interest to the following: electrical engineers engaged in electronic circuit design, development, and research, in government, industrial, and university laboratories; teachers and prospective teachers of electronics in colleges and universities; and graduate students interested in electronics.

The problem laboratory arrangement makes it possible to invite visiting lecturers to discuss various aspects of the problem in which they are uniquely qualified, without making them responsible for the problem and examination work of individual students. This permits using in combination the maximum capability of the visiting lecturer and at the same time the experience and the continuity in instruction provided by the teaching staff in residence at the university.

The instruction is essentially on the graduate level, the work being conducted for the benefit of men who already have a sound basic knowledge of electric circuit theory, gained either through formal course work or informally as an outgrowth of engineering research or teaching experience. Familiarity with and skill in using the basic theorems, in loop and nodal analysis, and in equivalent circuit manipulation, is assumed.

Material is organized into two courses: "Fundamental Physical Property of Transistors, and Pulse and Switching Applications"; and "Transistor Circuit Principles, and Application for Continuous Operation Service."

In the first course there are incorporated lectures dealing with the fundamentals of transistor operation and structure, with transistors as used for pulse functions (both junction and point-contact types), and lectures dealing with ratings, reliability, reproducibility, and future prospects for new devices. In the second course the treatment starts by introducing transistor circuit characteristics, continues with the small signal principles and applicational circuit design problems employing them, then proceeds to applicational and circuit design problems involving large signal continuous operation. At the end there is a review and integration of linear and pulse techniques.

Rain Produced in Pakistan by Seeding the Air With Salt

By blowing tiny salt particles into the air, in imitation of the evaporation of sea spray, scientists have succeeded in producing rain in Pakistan where the climate is too warm for the usual rain-making methods which utilize chemically produced snow.

Three years ago Pakistan had appealed to the United Nations Educational, Scientific and Cultural Organization (UNESCO) for a scientific mission to help solve the problem of drought. A UNESCO technical assistant, the British physicist Dr. E. M. Fournier d'Albe, and the Pakistan meteorologists with whom he worked realized that techniques used elsewhere could not be used in Pakistan. In colder climates, rain falls when the water in the clouds freezes and gets too heavy so rain-makers in those countries "seed" the tops of the clouds with chemicals and help produce snow in them. However, as Pakistan is too warm a country for this, it was necessary to find out how rain in warm countries is formed in the first place, and then to see whether the method might be imitated artificially.

The scientists suspected that rain in warm climates is formed on the tiny salt particles that come from the evaporation of sea spray. For 2 years, they took samples of the air in various parts of Pakistan to determine its sea-salt content. Near the sea coast, they noted, there were always thousands of salt particles in each cubic meter of air, but further inland, in the drought-frequented Punjab, there were far fewer—usually fewer than 10 per cubic meter.

Sealed tins of finely ground salt then were taken to wherever rain was needed, and the salt was simply blown into the air from the ground, or from the roofs of buildings. Small hand-blowers were used for this, and it was found that salt could be put into the air at the rate of a pound a minute. The whole apparatus for each rain-making station cost less than $30, and it was all made locally in Pakistan.

Last year Dr. d'Albe and his team made a test. For 2 months they seeded the air with the salt in two regions in the Punjab. An analysis of the daily reports from the country's rain gauges showed that the rainfall pattern was quite abnormal. In both test areas rainfall was 50 per cent higher than in neighboring regions, and a search of the records indicated that there had not been a similar occurrence in the last 40 years.

The scattering of the salt particles evidently had helped to produce a heavier rainfall. Pakistan now will be able to use this inexpensive and simple method regularly over a wide area, and so try to improve life for the harassed farmers of its dry regions.

77-Year-Old Dynamo Runs Again at Cornell Dedication of EE Unit

A dynamo which provided current for the first permanent outdoor electric lighting system in the United States ran again at Cornell University on June 11 for the dedication of Phillips Hall, the new classroom-laboratory center for the university's School of Electrical Engineering.

Ellis L. Phillips of Plandome, L.I., a Cornellian of the class of 1895 and founder of the Long Island Lighting Company, presented the building as a feature of Cornell's reunion-graduation weekend. The $1,650,000 structure is the third unit in a new quadrangle being created for the College of Engineering.

The Cornell-built dynamo gave the campus outdoor lights in 1878, well before their introduction in the great cities of the world. Just 3 years before, in 1875, Z. T. Gramme had brought out his famous dynamo in Paris. As soon as a description of it reached the United States, Professor William A. Anthony of the Cornell faculty and George S. Moler, a senior, undertook to

build a similar machine. Soon completed, the Cornell dynamo was exhibited at the Centennial Exposition in Philadelphia in 1876. Outdoor lighting of the campus began 2 years later and arc lights gave sputtering illumination from the tower of McGraw Hall and from the steeple of the original chapel.

The machine had a capacity of 20 amperes at 150 volts. It operated the campus lights for about 10 years, then was used for a time to furnish current for laboratory purposes. Successive members of the faculty have kept it in running condition since.

Mr. Phillips saw the dynamo in operation as an undergraduate, and its use at the dedication, against the backdrop of a modern electrical engineering building equipped with the latest in electronic devices, dramatizes the long strides electrical engineering has taken. In the new engineering center, there are individual laboratories for work in electronics, communications, illumination, power, servomechanisms, machinery, measurements, and other fields. The building also contains a network calculator laboratory, equipped with an a-c power network calculator and with a pipe-line network analyzer developed in the school. Altogether, there are 12 classrooms, 67 offices and small research rooms, 12 large research rooms, and 15 laboratories. The floor area is 94,000 square feet.

The building houses all the activities of the School of Electrical Engineering except its high-voltage, ionosphere, and radio-astronomy laboratories, each requiring special location.

Phillips Hall gives modern quarters to a school which pioneered in early electrical engineering. Until 1883, when the university formally authorized a course leading to a degree in electrical engineering, there had been no curriculum in this field in any institution. Establishment of a formal department of electrical engineering 6 years later marked the first such distinct organization of electrical engineering education.

First Offshore Radar Platform Ready for East Coast Installation

The first of the United States Air Force's "Texas towers" to stand offshore with radar aircraft-detection equipment was launched recently at Quincy Yard of Bethlehem Steel Company, Quincy, Mass. After being towed to the Boston Yard of Bethlehem Steel Company at East Boston, Mass., for inspection and final modification, the structure is scheduled to be towed out to sea and put in place about 100 miles east of Cape Cod, Mass., on Georges Bank, early in July.

Once in place the Texas tower will report tracks of all unidentified aircraft to the nearest shore-based aircraft control and warning squadron which will "scramble" jet fighter aircraft to intercept and positively identify the unknown planes. In addition, it will also serve as a weather collecting and reporting station.

The towers are designed to provide the Continental Air Defense Command with adequate warning of approaching enemy aircraft in order to intercept them before they reach coastal targets.

MODEL of triangular "Texas tower" platform to provide off-shore early-warning radar facilities. The three spherical radomes house radar and communication antennas.

This tower will be the first of several similar towers to be erected along the East Coast of the United States for the Continental Air Defense Command by the Navy's Bureau of Yards and Docks, acting as the construction agency.

The stations will be located approximately 100 miles off the coast and will be linked with the shore-based warning network used by the Continental Air Defense Command in the over-all defense of the United States.

Each station will include housing facilities for the warning and weather reporting equipment and sufficient shelter for a crew of more than 70 Air Force, Navy, weather, and Coast Guard personnel who will be stationed at the sites for 30-day periods or more. Space will be provided for helicopter landings and there will be docking facilities for the resupply of each station.

The long legs of the tower, reaching down to shoals along the continental shelf, will support a platform mounted 87 feet above water level, out of the reach of waves. The huge steel platform alone weighs 6,000 tons. Power-generating equipment and living accommodations for the men will be mounted on it. Included will be sick bays and recreation rooms.

Rising from the platform will be three radomes sheltering the radar antenna and radio-communications equipment.

The platform will be towed into position, with the legs sticking up in the air. When over the chosen site, the legs will be lowered through wells in the platform. Powerful hydraulic jacks will hoist the platform to the desired height.

To support the platform, which is triangular in shape, it was found that waves of the size selected for design criteria, exert terrific force on any supporting element in the water. This led to the choice of three supporting legs, the minimum number that will support a platform without cantilevering. The three legs, approximately 150 feet in length and 10 feet in diameter, will take the form of heavy columns filled with reinforced concrete.

Protection of these structures against corrosion is a major consideration. It has been determined that painting, combined with cathodic protection, is ample for all surfaces except those at the tidal and spray levels. In this critical area, the specifications call for a 35-foot length of Lukens 10 per cent Monel-clad steel, the same thickness as the balance of the columns. Monel was selected because of its excellent resistance to the corrosive effect of salt water, salt air, and salt spray. Also, along the outer circumference of the sheathing, designers specified pure Monel buffers to protect against floating objects which might surge against the pilng.

Although the first tower will not have cross-bracing between the legs, such braces will be necessary on future radar platforms located in deeper water. For this application, the designers have specified Monel sheathing for about 75 feet on each of six cross-braces. In addition to the sheathing on the braces, the pins which tie the links together under water will be made of corrosion-resistant Monel with the same material fastening the pins in position.

Detroit Edison Computes Bills on High-Speed Electronic Device

The Detroit (Mich.) Edison Company has started to compute customers' bills on a high-speed electronic office machine, it was announced recently. The company has installed an International Business Machines *650* magnetic-drum data-processing machine, the first of its type in the Detroit area. According to an Edison spokesman, this is the most advanced electronic office machine yet to be installed in any public utility.

The machine is installed in Edison's customers' billing department. It computes bills from the customers' current and past meter readings, introduced into the machine on punched cards.

The new processing device makes it possible for Edison to consolidate numerous existing mechanical operations. In addition, the machine performs mechanically some of the existing manual operations.

The *650* combines an advanced "memory" unit and a stored program feature. It can, in effect, remember 20,000 digits and recall any number for calculating purposes—according to "directions" from the stored program—in a split second.

One of the interesting features of the

machine as it is being used at Edison is its ability to determine whether the meter reading is consistent with past meter readings. If the reading is too high or too low, the machine sets aside records to be checked by clerks who decide whether a second meter reading should be made to check the accuracy of the first one. Where meter readings have not been secured, the machine automatically makes an estimate of the reading.

Scanner System Permits Pickup of Television Pictures in Color

A pickup of live television pictures in color, without using television cameras, was demonstrated recently by Allen B. Du Mont Laboratories, Inc. The system that did this so effectively was novel and inexpensive compared with regular commercial color studio cameras, and easy to operate. One man was the sole attendant at the operation.

Called the Du Mont "Vitascan" (registered trade-mark) color studio scanner, the new system is the reverse of a conventional television studio pickup system. Instead of receiving light through a lens, the scanner emits light from a cathode-ray tube. This beam of light scans persons, objects, or action in the studio, and the light that is reflected is picked up by means of multiplier phototubes. These tubes convert the reflected light into an electric signal which may be passed on to a standard color television transmitter for purposes of broadcast.

According to Du Mont engineers, Vitascan fulfills the requirements of television stations throughout the country for dependable inexpensive means of putting on local live programs of limited size from a studio, in full color. These programs include commercials, news commentaries, debates, and similar features. The system also permits broadcasting in regular black-and-white television.

The nearest thing to a video camera as far as resemblance is concerned, is a unit of the Du Mont equipment known as the studio scanner. This unit, which has a lens like an optical camera, directs light beams from the scanner over the studio scene. Spaced about the studio walls and ceiling are clusters of sensitive multiplier phototubes which catch and amplify red, blue, and green parts of the light rays reflected from the studio scene.

Arranged in clusters of tubes or in groups of four, the phototubes are equipped with sensitive color filters to make each one "see" one of the colors in the view. The resultant signal is sent on to the color video transmitter for broadcasting.

The registering of any one color exactly with another, an ever-present problem in regular color video cameras that requires the constant attention of trained experts and hours of warmup time, is an inherent electronic virtue of the equipment. With the Vitascan there is no such thing as being out of register.

Since the new color system operates wholly from the light of the flying-spot scanner, conventional studio light is not employed. This means that the studio actually is in darkness when the flying-spot is scanning the scene. Studio illumination for actors, speakers, and others in the studio during the broadcast is provided from an intermittent source.

Du Mont engineers solved this dilemma in an unusual way. They created a "fully lighted dark room." Since the spot of light is scanning the studio scene in rapid bursts of light with blanked-out intervals between, the engineers employ a high-speed intermittent light called a "sync-lite." The so-called sync-lite flashes on whenever the light from the studio scanner is blanked out.

When the studio scanner needs darkness it gets it. The performers also get the light they need. The human eye, as a result, sees a studio continuously and sufficiently lighted.

The Vitascan may be used by itself or as an integral part of an already widely used unit of Du Mont studio broadcast equipment called a "multi-scanner." When linked with this multi-scanner it gives the television station a single studio package that permits it to telecast the highest-quality television pictures in color or monochrome from live sources, from 16-mm films, from slides, or from opaques.

VITASCAN color studio scanner system (above) utilizes a beam of controlled light from a cathode-ray tube for scanning, then picks up the reflected light by multiplier phototubes such as the one at right.

First Automatic Sextant Will Aid Aerial Navigators

An experimental model of the first automatic sextant in the history of aerial navigation has just been designed and developed by Kollsman engineers, according to an announcement by Victor E. Carbonara, president of Kollsman Instrument Corporation.

"The first version of the new Kollsman photoelectric sextant," Mr. Carbonara said, "will give us information necessary for the development of production models. Recent tests on the prototype have been successful and indicate that the instrument will save time for the navigator, simplify his job, and reduce the possibility of human error. The device automatically sights and tracks the sun during the day and the stars and planets at night. Manual sighting of celestial bodies will not be necessary and the new sextant will retain its sight on a star and continue to track it automatically during and after changes in course. Also, flexibility of installation will be greatly increased.

"The navigator will read information directly from a remote indicating panel which is readily accessible to him. The remote panel contains all controls necessary for the sextant's operation and is the only part of the instrument to which the navigator must have access. It is the remote indicating feature that gives the sextant its greater field of observation. As the sextant tracking device need not be near the navigator, it can be installed in any section of the aircraft where it has an unobstructed view of the sky."

There are three components in the photoelectric sextant: the sextant tracking device, the indicator with the control panel, and the amplifier. Operation is simple. The navigator presets on the control panel the estimated position of the selected celestial body. Automatic operation then takes over. The sextant tracking device, which has a photosensitive telescope, searches for the star from which readings are to be taken. The telescope sweeps from right to left with several steps of elevation, searching a patch of sky seven degrees wide by five degrees high until it automatically recognizes the star to be tracked.

As soon as the star is recognized, the system starts its tracking operation. During this phase, an illuminated "T" is visible on the indicator. An automatic averaging period can be started at any time by throwing a toggle switch. When the averaging period is over, an "R" lights up on the panel, indicating that the navigator can "read" the average star altitude.

Because the photoelectric sextant will automatically retain a star when the aircraft changes course, repeat observations can be made with the same star, or the sun, a valuable asset for final determination of true heading. Whenever a celestial body is tracked in level flight, the system will measure accurate relative bearing. This information can be used by the navigator to determine true heading or star azimuth. The star telescope's photoelectric scanning system is designed so that aurora phenomena, haze, or moonlight have no effect on its function.

Very limited space and cumbersome pressure suits make it difficult for crew mem-

bers to move about during flight. The remote control of the photoelectric sextant enables the navigator to operate the sextant without leaving his station. He need not even stand up. Another advantage of the remote-control factor is that it eliminates serious problems of installation encountered with other types of sextants for which a transparent canopy must be pierced to accommodate the mount.

Tests show that under normal flight conditions, accuracy within 2 miles can be obtained with a running fix from a succession of several star shots.

NUCLEAR research reactor of the "swimming - pool" type, as seen in the artist's cutaway conception, provides flexibility for a wide variety of research and development.

Government Announces Availability of Fulbright Awards for 1956–1957

The U. S. Government has announced the availability of 1956–57 Fulbright Act grants for university lecturing and advanced research in Europe, the Near East, Japan, and Pakistan. Attention is particularly called to the earlier closing date for submitting applications, which has been advanced this year to October 1, 1955.

Ordinarily awards are made for a full academic year. These grants, which include round-trip transportation, maintenance allowance, and a small supplemental allowance for travel in the host country and purchase of books or equipment, may be made for only one country and arrangements will be made for those selected to be affiliated with an institution of higher learning abroad.

To be eligible, applicants must be U. S. citizens. Those applying for lectureships should have at least one year of college or university teaching experience. Applicants for research awards should have a doctoral degree at the time of application, or recognized standing in their profession.

Application forms and additional information may be obtained from: Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Avenue, Washington 25, D.C.

Nuclear Reactor Designed for the Battelle Memorial Institute

A nuclear research reactor has been started for the Battelle Memorial Institute, Columbus, Ohio, by the American Machine and Foundry Company, New York, N. Y. The target date for "going critical" is February 1, 1956. The reactor and its supporting laboratory facilities will constitute an $1.5-million atomic research center which Battelle is building 15 miles west of Columbus.

The reactor will be the so-called "swimming-pool" type modeled somewhat after the bulk shielding reactor at the Oak Ridge National Laboratory. It is designed to operate at flux levels as high as 1,000 kw on Uranium 235 solid fuel. Its core is similar to that in the materials testing reactor at the National Testing Station in Idaho.

Research reactors are essentially producers of radiation—neutrons, gamma, and beta radiations, and other radiations emitted from the inner structures of the atom. An important use planned for this reactor is to furnish an intense source of neutrons for conducting experiments on power-reactor cores necessary for the development of nuclear plants for generation of electric power.

The reactor is also designed to be of broad use in the study of the application of atomic energy to problems of industry. This new research tool makes possible investigations in materials, sterilization and pasteurization of foods, radiation in chemistry, biochemistry, and biology, radioisotope production, medicine, physics, and reactor technology. The reactor will also be used in Battelle's research for the chemical, petroleum, metals, machinery, ceramics, electronics, food processing, textile, and pharmaceutical industries. The intense radiation makes possible new exploration in the field of radiation-activated chemical reactions. It will provide radioisotopes for tracer studies in agriculture, medicine, wear and lubrication, and a wide variety of problems.

Use of Mass Spectrometer Extends Steel Industry Research

The first mass spectrometer to be used in the steel industry is now in operation at the United States Steel Corporation's Applied Research Laboratory in Pittsburgh, Pa. Acquired primarily for the analysis of coke-oven gas, the new instrument can be used to investigate the composition of gases, vapors, and liquid hydrocarbons. With this addition to its spectrometric equipment, the Applied Research Laboratory is now able to use spectrometry for qualitative and quantitative analysis of a wide variety of inorganic and organic substances in the form of solids, liquids, or gases.

This new spectrometer supplements the infrared and ultraviolet spectrometers, which are used to analyze mixtures of organic compounds. Specifically, the mass spectrometer in many cases can analyze complex mixtures of organic compounds, in the form of vapors or volatile liquids, more accurately and more quickly than the infrared or ultraviolet light spectrometers.

For the identification of crystalline inorganic comounds, the X-ray diffraction spectrometer is utilized. With this apparatus, distinctive patterns or "fingerprints" of the compounds in a sample can be obtained in about half an hour. These patterns of known compounds are kept on file, much like the FBI fingerprint file in Washington. Every day, through the effort of the American Society for Testing Materials in cooperation with other interested technical groups, more compounds are being charted and filed in a reference library which now contains the "fingerprints" of almost 10,000 different compounds. Of course, for the elemental analysis of inorganic materials to determine the percentage of metallic elements, the conventional light-emission spectrometer is employed. Similar files of reference spectra are available for infrared, ultraviolet, and emission spectrometry.

In the mass spectrometer, molecules of a compound are broken into ionized fragments by electron bombardment. The number of ionized fragments of each mass is measured, and from these data the types and amounts of different organic compounds in a gas or vapor mixture can be determined.

The sample of gas or vapor admitted to the spectrometer is subjected to pressure-regulating devices so that the operating pressure in the analyzer unit is of the order of a few hundredths of a micron. Molecular

MASS SPECTROMETER, recently installed by U. S. Steel, is shown here set for process monitoring. The graph shows a tracing and retracing of a peak of one mass.

flow of the sample is achieved by causing the gas or vapor to pass through a gold foil "leak" into the analyzer unit. The molecules are bombarded by a stream of electrons, and the resulting charged particles are separated into groups according to their masses (or more specifically, their mass-to-charge ratios).

The separation of the charged particles is effected by accelerating the fragments into a strong magnetic field. A charged particle traveling through a magnetic field will follow a curved path, the radius of which is determined by the mass of the particle, its charge, the strength of the magnetic field, and the accelerating voltage. In a magnetic field of constant strength, any charged mass can be made to follow a desired path by correct adjustment of the accelerating voltage.

In the mass spectrometer, the entire analyzer unit is in the field of a strong permanent magnet. The path traveled by a particle which is to be detected is determined by two fixed slits at an angle of 180° with respect to each other. Thus, by adjusting only the accelerating voltage, any desired mass can be caused to impinge on the detector or target plate which is located behind the second, or exit, slit. By continuously varying the accelerating voltage through a specified range, particles of different masses are successively focussed on the target plate.

At the target plate the charged particles lose their positive charges by taking up electrons. By measuring the resulting electron flow, a quantitative measurement of the number of particles of a specific mass is possible.

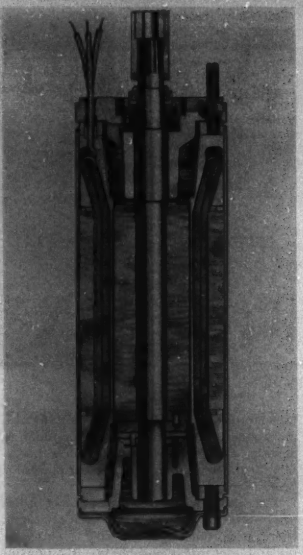
The electron flow is amplified and activates a pen on a moving chart. As the accelerating voltage is changed, automatically and at a specified rate, peaks representing all the masses produced by the fragmentation process are drawn on the chart.

For mixtures of substances, the resulting graph on the chart is a composite representation of all compounds present. This composite picture, through mathematical treatment, yields quantitative and qualitative data on the mixture.

In addition to its ability to analyze batch samples, this instrument can also be utilized as an integral part of a process stream to monitor or control a process. It can also be used as a leak detector.

New Submersible Motor Developed for Water Pumps

A new submersible motor has been perfected for water-well pumping by U. S. Electric Motors Inc. Incorporating standardized National Electrical Manufacturers Association mounting dimensions, the motor is of "wet"-type construction in which entrance of water into the motor will cause no harm to the windings. A special process has been developed for encasement of the copper windings in a plastic armor which is impervious to water within the motor. The plastic is a high-dielectric compound that has extremely low water absorption, similar to materials now used to jacket submerged power cables. The motor is immune to



CROSS-SECTION view of submersible motor

such hazards as leaky joints, wear of seals, condensation, impurities, vibration, etc.

To guard against internal corrosion, the motor is factory-filled with a highly stable emulsion of oil and water. The oil particles have a polar attraction to metal surfaces and deposit on them, preventing corrosion. Means are provided to maintain this emulsion at an effective concentration for a long period of time.

Weight of rotating parts and pump thrust is supported by a rugged thrust bearing of the tilting-shoe type and made especially for this motor. The radial bearings are of the hard babbitt sleeve type which contact the motor shaft of hard stainless steel, polished to a smooth finish. Because of the water/oil emulsion within the motor, there is no need to lubricate these motors either at the time of installation or any time thereafter.

A control box with heavy raintight enclosure and hinged lid is provided with each single-phase submersible motor. This control box contains the starting capacitor, relay, overload device, motor data, wiring diagram, and connection terminals. The submersible motor is available in ratings from 1/3 to 2 hp, single phase, and $1^1/_2$ and 3 hp, 3 phase.

Velocity of Light Redetermined by Use of Two New Methods

Two new determinations of the velocity of light have been made by National Bureau of Standards (NBS) scientists. Although carried out independently by widely different methods, the two determinations give precise values that are in close agreement. They also provide confirmation for the higher values of electromagnetic wave velocity that have been consistently obtained by microwave measurements since World War II.

In one method, the velocity of light was determined from measurement of the molecular constants of carbon monoxide by infrared spectroscopy. This work was carried out in the Bureau's Washington, D.C. laboratories by E. K. Plyler, L. R. Blaine, and W. S. Connor of the NBS staff. The other determination made use of phase-shift measurements on vhf radio waves to obtain their velocity of propagation. These measurements were made with a radio interferometer by E. F. Florman, of the NBS Boulder (Colo.) Laboratories, on a dry lake bed in southeastern Arizona. The Bureau's statistical engineering laboratory co-operated with both groups in analyzing the resulting data, and the Bureau's high-speed computer, SEAC, aided in the computations.

The velocity of electromagnetic waves has been a subject of investigation for many years. In the period preceding World War II, the value 299,776 ± 4 kilometers per second was generally accepted as an average of the findings of the various laboratories. However, since the war higher values have been obtained by most investigators, largely through measurement of the velocity of propagation of microwaves. Consideration of this more recent work has led to an average value of 299,793 ± 1 km/sec. The results obtained by the Bureau give 299,792 ± 6 km/sec by the molecular constants methods, and 299,795.1 ± 3.1 km/sec by the radio interferometer. They thus provide independent confirmation of the higher values obtained in other laboratories since World War II.

All-Silicone-Rubber Insulation Increases Rotating-Machine Life

Development of the first all-silicone-rubber insulation system has made it possible for Allis-Chalmers Manufacturing Company to build large motors and generators that work harder and last longer than conventional machines. Added life, reliability, and efficiency are achieved through the use of Silastic, the silicone rubber made by Dow Corning Corporation, to form the first completely homogeneous, rubbery insulation system for electric rotating machines.

Silicone (class *H*) insulation, long recognized as the most notable improvement ever made in insulating materials for electric machines, has previously been used only in combination with asbestos, fibrous glass, or mica. Such insulation systems are widely used in motors exposed to adverse service conditions and in both air-cooled and nitrogen-filled transformers.

Now, however, new procedures developed by Allis-Chalmers for insulating form-wound stator coils combined with significant improvements in the electrical and physical properties of Silastic have resulted in the first all-silicone-rubber insulation system. This new system gives large motors and generators greater overload protection and reliability plus maximum resistance to moisture, shock, and vibration, and to both electrical and mechanical fatigue.

The Silastic used in this insulation system

is made from a pure silicone rubber gum compounded with Dow Corning silica. Made by burning silicon tetrachloride in the presence of combustible gases, this silica filler is the purest form of silicon dioxide known and it has the finest particle size. As a filler for silicone rubber, it imparts maximum strength and tear resistance, and contributes to a combination of electrical properties that approach those of quartz.

This type of Silastic is applied to the entire coil structure and then vulcanized to form a homogeneous voidfree dielectric barrier. Built-up layers of dissimilar materials and binders are eliminated.

The added life and reliability of these new Allis-Chalmers motors and generators is due to the remarkable resistance of this insulation system to such deteriorating forces as heat, moisture, vibration, electrical and mechanical fatigue, abrasion, and corona, and it also permits a substantial increase in the power per pound ratio of rotating electric machines. This new insulation system is now available in Allis-Chalmers motors and generators in the 2,300- and 4,000-volt insulation classes.

This new type of insulation is of special interest to the continuous process industries and in pumping services where maximum reliability and efficient operation are most important. Lower installation costs and the virtual elimination of maintenance problems are important considerations in power plants and in pumping stations serving the petroleum industry, irrigation, and sewage disposal plants.

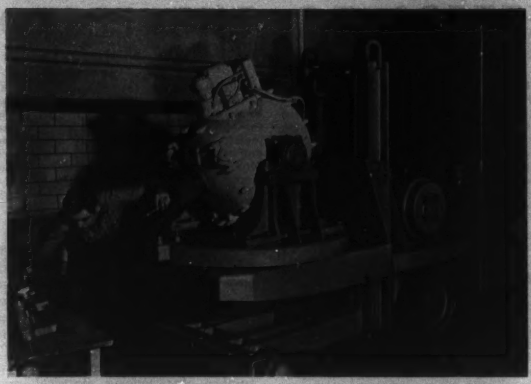
Wherever dust and abrasive conditions are a serious problem as in cement plants, rubber compounding, and mining operations, electric machines built with this all-silicone-rubber insulation system have unique advantages.

Cobalt 60 Is Utilized in Powerful New Inspection Tool

A new inspection tool which makes use of radioactive Cobalt 60 and is capable of radiographing—or "seeing through"—thickness of steel up to 7 inches, has been developed by The Babcock and Wilcox Company. The unit has been christened the "Isoscope" a derivation of the words "isotope," a radioactive material, and "scope," for the power to see through metals. The Isoscope, which has been under study and development for the past 3 years, requires only one third the exposure time of a 1,000,000-volt X-ray unit and paves the way for wider use of atomic energy in this industrial application at a lower initial cost.

The largest allocation of radioactive Cobalt 60 ever authorized to industry for radiographic work was assigned to Babcock and Wilcox for the Isoscope at Oak Ridge National Laboratory on October 11, 1954. The material was loaded into a special dual-purpose spherical lead container designed and built by the company's Barberton, Ohio, works to handle the radioactive material during shipment. The container is converted into a part of the radiographic machine upon arrival at its destination.

The lead sphere of the Isoscope is encased in a steel jacket having a cylindrical rotor section built into it. By revolving the rotor 180 degrees, the radioactive source can be brought from the safe position to a point in line with the coned opening in the steel jacket allowing a beam of radiation to escape. This, in effect, results in a unit which can be turned on and off.



ISOSCOPE, which makes use of radioactive Cobalt 60, is aimed at a test specimen.

The total charge placed in this unit was 1,008 curies of Cobalt 60. The charge is comprised of small disks stacked one on top of the other like coins in a coin changer. The radiation is taken from the top of this stack so that the focal-spot size compares favorably with existing high-voltage X-ray equipment.

The balance of the Isoscope consists of a modified electric platform lift truck having a lead cab built on the back and a turntable mounted on the front platform. Trunnions on the turntable receive the lead ball containing the radioactive material. Cover plates mounted on top and bottom of the lead balls carry the cylindrical rotating mechanism. This assembled unit can be raised or lowered through 8 feet, rotated vertically through 210 degrees and horizontally through 360 degrees.

The lead cab provides protection for the operator and contains controls for the operation of the machine. The controls consist of a timer, an on–off button, and a green, amber, and red light system which informs the operator of the position of his source at all times.

Improved Transistors Can Be Used in High-Frequency Applications

Transistors recently developed at the General Electric Research Laboratory, Schenectady, N.Y., can be used in television, radar, short-wave radio, and other electronic devices where high-frequency requirements previously required bulkier vacuum tubes.

Speaking at the dedication of the GE Electronics Division's new Stanford Microwave Laboratory, Dr. C. G. Suits, who is a General Electric vice-president and director of research, said, "Transistors made by the new 'meltback' process can operate efficiently at frequencies five times higher than ordinary transistors, and at these high frequencies the new transistors show greatly improved power-amplification characteristics."

Developer of the "meltback" principle is Dr. Robert N. Hall of General Electric, who also developed the "rate-growing" process for making junction transistors.

"Meltback" significantly improves the control of impurities in the thin layers of germanium or silicon crystals from which transistors are made. These crystals are smaller than a grain of wheat, and some layers must be as thin as 1/5000th of an inch for satisfactory performance at high frequencies.

In previous processes, crystals were formed from a pool of molten metal, and the layers created by cycling the rate of growth. Scientists have been faced with the problem of keeping materials in different layers from contaminating each other during the 20 minutes it takes the molten mass to solidify and cool to room temperature. This has meant thicker separating layers than are desirable for high-frequency use. In Hall's new process, the cooling time is greatly shortened, there is less intermixing between layers, and the layers therefore can be thinner. Thin layers allow electrons to travel more quickly from one side of the crystal to the other, thus increasing the frequency at which the transistor can operate.

Commercial methods previously available for making transistors involved the production of cigar-sized crystals of germanium or silicon and cutting them into thousands of tiny pieces. Hall's new method uses thin wirelike crystals, and because of the reduced cross section the "melting back" is accomplished quickly and cooling takes place not in 20 minutes, but in less than a second. In this short time the number of impurities migrating from their proper layers into adjoining layers is reduced to about 1/30th the former figure. The entire cycle of melting, cooling, and removal of the finished pellet takes only a fraction of a minute.

"Meltback" transistors also have greatly improved "gain" characteristics. Amplification of current with ordinary transistors usually is approximately 50 times.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Short-Circuit Analysis

To the Editor:

In short-circuit analysis it is customary to use the fully offset value of the fault current as representing the most severe conditions that it is possible to meet in practice. This assumption is made so commonly, being, in fact, the usual design premise, that it is apt to be taken as the theoretical limit. Typical of this is a paper by M. J. Lantz, "Power System Fault Current Analysis Including Study of Transient Offset," which has received the recommendation and approval of several AIEE committees (AIEE *Transactions*, vol. 73, pt. 3 B, 1954, pp. 1073–8).

In discussing the change in the rms current due to the d-c component, Mr. Lantz states: "The maximum theoretical current increase at time zero is $\sqrt{3}$ times the symmetrical value." I should like to point out that this is not necessarily the theoretical limit, nor is the numerical value $\sqrt{3}$ correct as Mr. Lantz has used it. Let us deal first with the numerical value, as we can dispose of this rather quickly. The value $\sqrt{3}$ is so well known as the *ratio* of the rms value of the fully offset current to the rms value of its a-c component that I am surprised to find Mr. Lantz calling it the *difference* between two values. Yet this is what he does, in substance, by twice calling it the *increase*, once in the statement quoted above, and once in the statement just previous in his paper, referring to Fig. 3. To be sure, Fig. 3 calls this a multiplier, but it does not identify the current of which it is a multiplier. I am sure that Mr. Lantz used the term "increase" in a manner in which he did not intend, and will agree that he had *ratio* in mind.

Mr. Lantz's analysis and tests deal with cases in which the load current was zero before the instant of short circuit. In such cases the fully offset value is the maximum that can occur, but I do not consider it good policy to call it the theoretical maximum without some sort of qualifying statement. Not only is it theoretically possible to get a more than fully offset current, but there are many cases commonly met in practice where the extent by which the offset may exceed 100 per cent can be sufficient to become a significant factor.

It is well known that the value of the d-c component is the difference between the instantaneous values of the load current and the short-circuit current at the moment of short circuit. The occurrence of the short circuit represents an analytical discontinuity—on one side of which the current has the value corresponding to the load current, and on the other side corresponding to the short-circuit current. Due to relative direction of power flow, relative magnitude, and relative power factor, these two currents may have widely divergent instantaneous values. The actual current in the circuit can neither change instantly from one to the other, nor have both values simultaneously. We therefore introduce the concept of a d-c transient whose initial value is the required difference.

This is explained in most comprehensive treatments of the over-all subject of short circuits, but I have been surprised at the number of practicing electrical engineers I have encountered who are not too clear on the matter. There are a number of ways of looking upon this d-c transient. It can be looked upon as a mathematical convenience, resulting from the analytical study. More realistically, it might be considered as the mechanism by which the electromagnetic conditions of the circuit change from the pre- to the post-short-circuit status. Or, if one prefers the philosophical aspect, one might say that it satisfies the requirement that there be no discontinuities in nature, even though there may be in our analysis. Regardless of viewpoint, however, it possesses reality. Oscillograms show the offset current. We also know that the d-c component contributes to conductor heating and the magnitude of the physical forces, and is a factor in circuit-breaker interrupting duty for the very fast circuit breakers. It also introduces a fundamental-frequency force in addition to the twice-fundamental-frequency force common to a-c systems. This was pointed out some time ago by the writer[1] and previously developed in connection with an unpublished undergraduate thesis (by H. R. Tomlinson and W. A. Tripp, Massachusetts Institute of Technology, June 1922).

The test data on the offset current reported in Mr. Lantz's paper are, basically, an experimental probability study for the case of zero load current. The per cent offset curves correspond to one form of probability curve. Let us consider, however, the case in which the load current (the pre-short-circuit current) is not zero. The factors which influence the magnitude of the d-c component, other than the time on the voltage wave, are, as stated above, relative direction of power flow, relative magnitude, and relative power factor. Cases in which these assume an importance usually arise when dealing with connecting links in a system having a multiplicity of sources. In these links the load currents are relatively large, while the short-circuit capacity is only that imposed by a portion of the system. Usually the flow of power under both load conditions and short circuit can have either direction in these links. Since the value of the d-c component is determined by the difference between the load and short-circuit currents, it is necessary, for theoretical maximum conditions, to assume the case in which they are in opposite directions. If the load current happens to be of not too high power factor, the situation is aggravated.

A typical, and common, example of such a case would be a generating station having several generators and transmission lines, all tied together in a switchyard which is sectionalized into, say, two parts. The sectionalizing link often will have a load capacity large in comparison with the size of any one generator. But the short-circuit current through the link can be that due to only the generators and system contribution from one side. The short-circuit analysis for the link will be based on only that part of the system, but in treating those items for which the offset current must be considered, an error of substantial magnitude would occur in neglecting the fact that the load current and short-circuit current can be in opposite directions.

The importance of this is perhaps greatest in connection with the calculation of short-circuit forces. It is true that the maximum force does not necessarily occur under the conditions which produce the maximum offset, particularly in the case of polyphase systems. This also was pointed out in the reference mentioned above (also derived from the unpublished thesis). This has been concurred in and quoted[2] and is taken into account in the formulas now in general use by the industry. However, the amount of offset for any conditions will be in proportion to the possible maximum, and therefore the force calculations would be proportionately incorrect if the analysis of the maximum is incorrect. It may be well to mention that the industry formulas are based on only 100-per-cent offset and must be adjusted before being applied to special cases such as those mentioned here. Perhaps the most useful concluding thought would be to emphasize that it is important to recognize these special cases when they are encountered, to know wherein our usual design premises must be adjusted, and to know how to make the necessary adjustments.

WILLIAM A. TRIPP (M'35)

(Ebasco Services, Inc., New York, N. Y.)

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2. Forces on Conductors During Short-Circuit, S. C. Killian. *Delta-Star Magazine*, Pittsburgh, Pa., January–February 1943, pp. 493–7.

Induction Generators

To the Editor:

I found the paper, "A Self-Excited Induction Generator with Regulated Voltage" by H. M. McConnell (AIEE *Transactions*, vol. 73, pt. 2, 1954, pp. 288–95), which arrived here only recently, very interesting indeed.

The initial voltage build-up of such a generator and its generating voltage depend to a high degree on the saturation of its main magnetic circuit or on the fact that X_m is not a constant, but unfortunately no details are given in this respect.

I have published an investigation of the self-excited induction generator (I treated shunt condensor excitation only) a few years back ("Das Verhaltan des kondensatorerregten Drehstromasynchrongenerators: The Performance of the Self-Excited Induction Generator," *Elektrotechnik und Maschin-*

enbau, Vienna, Austria, 1952, p. 505) and I assume that the author has not seen this article, which might give him some additional information. One result of my investigation was that there is a limit of load for such a generator in form of a critical load impedance (for resistive and inductive loads). If the load impedance is permanently reduced below its critical value, the generator loses its voltage.

In the case of a series capacitance a load short circuit will make this capacitance more effective and maintain the excitation of the generator, unless the inductance of the magnetic amplifier more than compensates this effect.

BENNO GERSTMANN (AM'41)

(Caulfield Technical School, Melbourne, Victoria, Australia)

To the Editor:

I am grateful to Dr. B. Gerstmann for his interest in my work on induction generators. His own article only recently came to my attention.

With regard to the variable nature of the magnetizing reactance X_m, I should like to point out that the use of a controlled shunt reactor as a regulating scheme allows automatic compensation of changes in X_m. It is only necessary to set the design so that in normal operation the saturation is not excessive.

As Dr. Gerstmann has shown, the induction generator may be operated at reasonably constant voltage with varying load and with fixed-shunt capacitor excitation, if the machine is sufficiently saturated. The use of saturation to regulate voltage is quite analogous to the same situation encountered in the shunt-excited d-c machine.

Dr. Gerstmann's paper also shows that the induction generator loses excitation if the load current exceeds a certain critical value (Fig. 8 of his paper), under conditions of fixed shunt capacitance. The system described in my paper exhibits a similar property; at high load current, the machine demands more kilovar input to balance the rotor reactive current, in addition to the kilovars demanded by the load. The combined demand exceeds the capability of the kilovar generators (capacitors) at a critical load, and excitation is lost. As explained in my paper, and as amplified in the discussion by Messrs. Lytle, Caldwell, and Byloff, the use of series capacitors raises this load limit.

H. M. McCONNELL (AM'48)

(Carnegie Institute of Technology, Pittsburgh, Pa.)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

THE DESIGN AND ANALYSIS OF INDUSTRIAL EXPERIMENTS. Edited by Owen L. Davies. Hafner Publishing Company, 31 East 10th Street, New York 3, N. Y., 1954. 636 pages, 10 by 6¼ inches, bound. $10.00. A sequel to the editor's Statistical Methods in Research and Production (1947), this book applies some of the simpler techniques discussed in its predecessor to the arrangement of items comprising a complex experiment and to the analysis of results. Problems considered include planning simple comparative experiments, sequential testing, factorial experiments, and determination of optimum conditions. Experimental methods are not dealt with. Although the numerous examples given are drawn exclusively from the chemical industry, basic principles are explained in general terms applicable in other fields.

ENGINEERING CYBERNETICS. By H. S. Tsien. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1954. 289 pages, 9½ by 6¼ inches, bound. $6.50. This study, presented on the mathematical level of the research engineer, is concerned with the parts of cybernetics which have direct engineering applications in designing controlled or guided systems. The emphasis is on theoretical analysis and on the principles underlying different areas of practice rather than on the design and construction of components. Some of the topics treated are non-interacting controls of many variable systems, nonlinear servomechaniams, control design by perturbation theory, noise filtering, and theory of error control.

EXPERIMENTS IN ELECTRONICS AND COMMUNICATION ENGINEERING. By E. H. Schulz, L. T. Anderson, and R. M. Leger. Harper and Brothers, 49 East 33d Street, New York 16, N. Y., second edition, 1954. 342 pages, 9½ by 6¼ inches, bound. $6.00. Originally prepared for use in training men for the Signal Corps, this text has now been revised for use in college courses in electronics, communication networks, radio, and uhf phenomena. Ninety-three experiments are given, with discussion of principles, suggested procedure, and suggested apparatus.

FEEDBACK CONTROL SYSTEMS. By Gilbert Howard Fett. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y., 1954. 361 pages, 8½ by 5⅞ inches, bound. $10.00. An introduction to the subject for advanced students and for practicing engineers seeking a basic understanding of the field. The equations of components are developed, and separate chapters are devoted to steady state and transient solutions, the Nyquist criterion for stability, and stability diagrams. Concluding chapters deal with complex and nonlinear systems. Chapter bibliographies are included.

GEOLOGY OF PETROLEUM. By A. I. Levorsen. W. H. Freeman and Company, 549 Market Street, San Francisco 5, Calif., 1954. 703 pages, 9½ by 6¼ inches, bound. $8.00. Primary attention is given in this text to the principles that aid in understanding the geologic history of an area—its stratigraphy, sedimentation, deformation, and fluid phenomena—and to principles used in the discovery process. The main divisions of the book cover the reservoir, with emphasis on the trap; reservoir temperature, pressure, and fluids; origin, migration, and accumulation; and applications in the search for new pools and provinces. Chapter bibliographies are provided.

HOW TO READ ELECTRICAL BLUEPRINTS. By Gilbert M. Heine and Carl H. Dunlap. Revised by C. S. Jones. American Technical Society, 848 East 58th Street, Chicago 37, Ill., second edition, 1954. 311 pages, 8½ by 5⅝ inches, bound. $4.75. The major part of this book is devoted to the explanation of symbols used to represent the various pieces of electric equipment that must be indicated on electrical blueprint. The material is divided into ten sections, each dealing with a branch of the electrical industry—house wiring, generators and motors, power stations, etc. A new feature in this edition is the presentation of pages of symbols with the objects they represent printed opposite each symbol.

INDUSTRIAL DESIGN. By Harold Van Doren. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., second edition, 1954. 379 pages, 10¼ by 7½ inches, bound. $6.50. This book is aimed at the young person choosing a vocation and also at engineers, draftsmen, and others with design problems to solve. It outlines the principles, techniques, and procedures to be followed in analyzing, creating, and developing products for mass manufacture, including consumer goods, capital goods, commercial or service equipment, and transportation equipment. New chapters have been added on predesign research, independent analysis, merchandising, and testing consumer reaction to a proposed design.

LAMPS FOR A BRIGHTER AMERICA. A History of the General Electric Lamp Business. By Paul W. Keating. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1954. 246 pages, 9½ by 6 inches, bound. $4.00. A history for the general reader recording both technical advances in lighting and the growth of General Electric Lamp Division as a business organization. Early experiments are described, including Edison's work on the first practical incandescent lamp, and there is discussion of the development of special types of lamps-lens-end flash bulbs, sun lamps, sealed beam headlights, and others.

LAPLACE TRANSFORMS FOR ELECTRICAL ENGINEERS. By B. J. Starkey. Published for *Wireless Engineer* by Iliffe and Sons, Inc., London, England, 1954. 279 pages, 8½ by 5½ inches, bound. 30s. An introductory treatment of a mathematical tool which has become useful for a wide range of engineering and physical problems. The development of the theory is logical. The approach and the vocabulary are from analytical methods with which many engineers are familiar, and illustrative applications are freely used. The book will serve both as a practical text or as an introduction to a fuller mathematical treatment.

MACHINE DESIGN. By Vladimir L. Maleev and James B. Hartman. International Textbook Company, Scranton, Pa., third edition, 1954. 706 pages, 9½ by 6¼ inches, bound. $8.50. The six main divisions of this text deal with stresses and materials, manufacture of machine parts, fastenings, details for handling fluids, hoisting machinery, and power transmission machinery. Coverage has been extended to include developments in many fields, including the unified screw-thread system, new fastening devices, involute splines, and new materials such as ductile iron and various aluminum alloys. Two new chapters have been added to the section on manufacturing processes.

MAGNETIC CONTROL OF INDUSTRIAL MOTORS. By Gerhart W. Heumann. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., second edition, 1954. 714 pages, 9¼ by 6 inches, bound. $9.50. Provides exhaustive coverage of electric motor performance, control device characteristics, and functions of commonly used control circuits, with emphasis on considerations governing the selection of controllers for specific purposes. The text has been revised in line with present-day practices and includes new material on adjustable voltage and regulating systems. Obsolete designs have been eliminated, and tables and diagrams have been changed to conform to the latest industrial standards.

MASS SPECTROMETRY. By A. J. B. Robertson. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 135 pages, 6½ by 4⅝ inches, bound. $2.00. This small volume, a general introduction to the subject, includes a brief historical review of the method, and concise chapters on the operation of mass spectrometers, on the ionization and dissociation of molecules induced by electron impact, and on the use of the technique in chemical analysis, free radical investigations, and measurement of isotopic abundances.

AUTOMATIC VOLTAGE REGULATORS AND STABILIZERS. By G. N. Patchett. Sir Isaac Pitman and Sons, Ltd., London, England., 1954. 335 pages, 8½ by 5⅓ inches, bound. 50s. The subject is broadly defined to cover any device for maintaining automatically a constant or predetermined voltage at some point, whether on large power systems or in small electronic appliances. The three sections of the book deal with principles, electromechanical regulators, and regulators with electric and electronic circuits only. Both continuous and discontinuous types are treated. Over 600 references are listed at the end of the text.

BASIC ENGINEERING SCIENCES. By William Glendinning, 5123 Bell Boulevard, Bayside, N. Y., 1954. 126 pages, 11 by 8½ inches, paper. $3.00. Problems, with solutions, selected from Part II of New York State Examinations for Engineer-in-Training and Professional Engineer, 1945–June 1954. They cover various aspects of hydraulics, thermodynamics, machine design, and electrical principles and equipment, with specific problems on stream flow, heat transfer, mechanical movements, generators and motors, etc.

A HISTORY OF TECHNOLOGY. Volume I: From Early Times to Fall of Ancient Empires. Edited by Charles Singer, E. J. Holmyard, and A. R. Hall. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y., 1954. 827 pages, 10 by 7½ inches, bound. $23.55. This is the first of five volumes which will record the history of how things have been done and made from the earliest times through the 19th century, with the object of showing how the complex technical knowledge of our civilization has come into being. A vast amount of information has been co-ordinated and presented in scholarly fashion by the wide range of authorities who contribute the separate chapters of the work. The present volume covers man as hunter and as builder of settled societies, and treats fully the

technology of the first civilizations of the Near East. Such subjects as water supply, use of metals, transport, writing, weights and measures, mathematics, and many others are discussed in their origins and early development. Over 500 textual figures and a number of plates are included.

INDUSTRIAL AUTOMATIC CONTROLS. By Millard H. LaJoy. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y., 1954. 278 pages, 8½ by 5¼ inches, bound. $6.65. A text for a first course, requiring no mathematics beyond calculus and ordinary differential equations. Basic modes of control—two position; proportional, floating, and rate—are analyzed, and characteristics of controller combinations are described. There are chapters covering the internal circuitry of pneumatic, hydraulic, and electronic controls, and a separate chapter surveys representative applications in the ceramic, chemical, food, power, and textile industries. The last two chapters are introductions to the theoretical analysis of industrial processes and controlled systems.

MAGNETIC AMPLIFIERS AND SATURABLE REACTORS. Edited by M. G. Say. George Newnes Ltd., London, England, 1954. 199 pages, 8½ by 5¼ inches, bound. 21s. A summary of recent information on the principles, construction, and application of these devices. Separate chapters, each prepared by an authority on the subject, cover magnetic principles, basic circuits, construction of transductors, push-pull amplifiers, and magnetic modulators. Two chapters on control and instrument applications deal with the use of saturable reactors for electric power, motor speed, machine, and welding control, and for current metering, servomechanisms, and various other purposes.

METALLURGY OF THE NON-FERROUS METALS. By W. H. Dennis. Sir Isaac Pitman and Sons, Ltd. (distributed in U.S. by Pitman Publishing Corporation, 2 West 45th Street, New York 19, N. Y.) 1954. 647 pages, 8¼ by 5½ inches, bound. $12.50. This up-to-date, practical book for students, metallurgists, and engineers deals with the metals roughly in order of their industrial production, beginning with copper and ending with the rare earths and radium. Information is given on source, extraction operations, refining, and, for the major metals, properties, alloys, and uses. American metallurgical practice is given prominence in the text.

NUCLEAR GEOLOGY. A Symposium on Nuclear Phenomena in the Earth Sciences. Edited by Henry Faul. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 414 pages, 9¼ by 6 inches, bound. $7.00. Twenty-six scientists have contributed to this symposium which is intended as an introduction to the subject for the graduate student and practicing geologist. It includes a simple introduction to nuclear physics; an outline of such important techniques as nuclear emulsion, mass spectrometry, and isotope dilution; discussion of radioactive elements in rocks and oceans; and description of thermal, physical, and chemical effects; radioactivity. Separate chapters treat nuclear methods of exploration and well logging, absolute age determination, and the origin of the earth. An extensive bibliography is appended.

OPERATIONS RESEARCH FOR MANAGEMENT. Edited by Joseph F. McCloskey and Florence N. Trefethen. Johns Hopkins Press, Homewood, Balt. 18, Md., 1954. 409 pages, 9¼ by 6 inches, bound. $7.50. A 3-part study based largely on lectures delivered by industrialists, engineers, and others in a seminar at Johns Hopkins University in 1952. Part one covers the scope and history of the field, and the relations between management and the operations analyst. The second part deals with methodology and the use of information theory, computing machinery, linear programming, game theory, and other techniques. Part three is made up of case histories drawn from the printing industry, the reliability of air-borne radar, sales promotion, etc. The selected bibliography includes references through September 1954.

ANNUAL REVIEW OF NUCLEAR SCIENCE. Volume 4, 1954. Edited by James G. Beckerley. Annual Reviews, Inc., Stanford, Calif., 1954. 483 pages, 9 by 6½ inches, bound. $7.00. The 17 papers in the present volume are essentially surveys of the literature on recent developments, accompanied by extensive reference lists. Three of the papers are devoted to different aspects of nuclear particle detection, and there are papers on penetration of heavy charged particles in matter, radioactivity in geology and cosmology, and on various other topics. Author and subject indexes covering the entire volume are included.

RELAIS UND SCHUTZSCHALTUNGEN IN ELEKTRISCHEN HOCHSPANNUNGSANLAGEN. By Walter Bütow. Verlag G. Braun, Karlsruhe, Germany, 1954. 234 pages, 9¾ by 6 inches, bound. DM 24.00. This volume, one of a series on high-voltage technology, deals with relays and protective circuits in high-voltage plants. Following a discussion of faults in power supply networks the book takes up the operation and construction of relays and provides a guide for the selection of correct equipment. Overload protection, automatic reclosing, relay testing, the protection of transformers and generators, and specialized types of relays are other topics considered.

REPORTS ON THE PROGRESS OF APPLIED ELECTRICITY. Volume XXXVIII: 1953. Society of Chemical Industry, London, England. Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y. 989 pages, 8½ by 5½ inches, bound. $6.50. In this broad summary of the literature covering developments in 1953, the topics most likely to interest engineers include: fuel and fuel products; iron and steel; non-ferrous metals; corrosion; electrochemical and electrometallurgical industries; ceramics and refractories; industrial gases; road and building materials; rubber; adhesives; plastics; paints; fluid flow; heat transfer; industrial instruments and automatic control; and water treatment. A detailed subject index is provided.

RICCI-CALCULUS. An Introduction to Tensor Analysis and its Geometrical Applications. By J. A. Schouten. Springer-Verlag, Berlin, Germany, second edition, 1954. 516 pages, 9¼ by 6½ inches, bound. DM 58.60. A comprehensive survey of the Ricci calculus in its modern form. Taken up in order are algebraic preliminaries, including a section on hybrid quantities; important analytical notions; linear connections, curvature, and normal co-ordinates; the theory of the Lie groups; and imbedding and the theory of higher curvature. The remainder of the book deals with projective and conformal transformations of connections; the theory of variations, deformations, and movements; and miscellaneous examples from recent literature, including Kron's applications of tensor analysis to electric circuits. A bibliography of some 1,400 references is given.

SIGNAL, NOISE AND RESOLUTION IN NUCLEAR COUNTER AMPLIFIERS. By A. B. Gillespie. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1953. 155 pages, 8¼ by 5¾ inches, bound. $4.50. The first in a new series of monographs, "Electrons and Waves," this book is an attempt to give a thorough yet simple treatment of the subject. The three chapters on detection principles, signals from ionization chambers, and proportional and scintillation counters are to some extent a summary of previously published information. The remaining three chapters—on noise, signal to noise ratio, and resolution and sensitivity—are based largely on unpublished theoretical and experimental data. A list of references is included.

STARKSTROMPROBLEME BEI SCHWEISSMASCHINEN. (Mitteilungen Aus Dem Institut Für Elektromaschinenbau an der E.T.H., no. 3). By Stanislaw Owczarek. Verlag Leeman, Zurich, Switzerland, 1953. 95 pages, 9¼ by 6½ inches, paper. Sw.Frs. 12.50. This thesis on high-voltage problems in welding machines reviews the theoretical principles involved in the design of both arc and resistance types. The last two chapters deal with the fundamentals of electronic control of resistance-welding machines and with high frequency in the arc-welding process.

TELEVISION AND RADAR ENCYCLOPEDIA. Edited by W. MacLanachan. Pitman Publishing Corporation, 2 West 45th Street, New York 19, N. Y., second edition, 1954. 216 pages, 8¼, by 5½ inches, bound. $6.00. A number of new terms have been added in this edition, and others have been revised in order to take into account latest practices. As in the previous edition, the book lists in a single alphabet brief definitions and longer signed articles on terms in common use in the United States and Great Britain. Sketches, diagrams, and photographs are used for illustration, and an appendix includes a list of symbols, tables of inductances, and other pertinent data.

THE THEORY OF COHESION. An Outline of the Cohesive Properties of Electrons in Atoms, Molecules, and Crystals. By M. A. Jawson. Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y., 1954. 245 pages, 8½ by 5¼ inches, bound. $5.75. This monograph develops, on an intermediate level, the mathematical and physical arguments involved in the wave mechanical theory of cohesion. It proceeds from relatively elementary principles to a full treatment in aggregates and particularly in metals. Subjects covered include some important concepts of wave mechanics, the helium atom and hydrogen molecule, cohesive forces in alloys, elastic constants of metallic materials, cohesion in transitional metals, and covalent structures.

BASIC CIRCUITRY OF THE MIDAC AND MIDSAC. By J. E. De Turk and others. University of Michigan, Engineering Research Institute, Willow Run Research Center, Ypsilanti, Mich., 1954. Various paging, 11 by 8½ inches, paper. $2. This report describes the electronic computing circuits used by the Michigan Digital Automatic Computer, a general-purpose electronic calculator, and the Michigan Digital Special Automatic Computer, designed for real-time operation as an element of an automatic control system. The computing circuits described consist of a group of pulse circuits which operate at a 1-megacycle pulse repetition rate. The four parts of the report cover the function, operation, and design of the packaged circuitry; examples of functional units within a computer; a simplified serial-binary arithmetic unit as an example of a computer subsystem; and mechanical design.

X-RAY DIFFRACTION PROCEDURES. For Polycrystalline and Amorphous Materials. By Harold P. Klug and Leroy E. Alexander. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 716 pages, 9½ by 6 inches, bound. $15.00. Numerous and varied procedures and applications are described in detail in this volume prepared for the plant worker, graduate student, and research scientist. The book includes an introduction to crystallography and X rays, and extended coverage of the Geiger-counter spectrometer, small-angle scattering methods, radial-distribution techniques, analysis of powder mixtures, precision determination of lattice constants, and recent developments in crystallite size determination. Examples are freely used to illustrate concepts and procedures.

THE YOUNG ENGINEER. Simplified Science and Engineering. By Charles B. Broschart. Exposition Press Inc., 386 Fourth Avenue, New York 16, N. Y., 1954. 243 pages, 8½ by 5½ inches, bound. $3.00. In this book, written for the father with a questioning son, answers to a wide variety of questions, such as "What makes an airplane stay up?" and "How does a steam engine work?", are presented in a language that a boy or young man can readily understand. The author, an electrical engineer, has included a good deal of information in relatively small compass on ships, engines, automobiles, natural phenomena, electric devices, and other subjects, thus making the book useful also as a means to interest boys in engineering as a career.

ADVANCES IN ELECTRONICS AND ELECTRON PHYSICS. Volume VI. Edited by L. Morton. Academic Press Inc., 125 East 23d Street, New York 10, N. Y., 1954. 538 pages, 9¼ by 6 inches, bound. $11.80. The title of this year's volume has been changed from "Advances in Electronics" in order to express the coverage of the series more clearly. As in previous years, the present volume includes critical reviews of developments in a variety of fields; namely, metallic conduction at high frequencies and low temperatures; relaxation processes in ferromagnetism; physical properties of ferrites; space-charge-limited currents; traveling-wave tubes; comparison of analogous semiconductor and gaseous electronics devices; the electron microscope; and paramagnetism.

ALTERNATING-CURRENT AND TRANSIENT CIRCUIT ANALYSIS. By Harris A. Thompson. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1955. 317 pages, 9¼ by 6¼ inches, bound. $6.75. A textbook for a first course in the subject for students with the usual preparation in physics, d-c circuit analysis, and differential and integral calculus. Essentials of a-c circuit analysis are presented with emphasis on the student gaining proficiency in their application, and transient analysis is developed from traditional methods in which the basic behavior of electric circuit parameters is emphasized. A chapter on mathematical analogues is included.

AMERICAN MEN OF SCIENCE. Volume I: Physical Sciences. Edited by Jaques Cattell. R. R. Bowker Company, 62 West 45th Street, New York 36, N.Y., 1955. 2,180 pages, 11¼ by 7¾ inches, bound. $20. When complete in three volumes, the new edition of this standard biographical directory will contain almost double the number of names in the previous (1949) 1-volume edition. The present volume includes over 43,000 biographies of living Americans and Canadians who have contributed to the advancement of physics, mathematics, chemistry, biological chemistry, meterology, oceanography, acoustics, and research engineering.

Authoritative information is given on date of birth, marital status, number of children, position, education, professional background, special fields of research, and society membership. Volumes II and III, to be published, will cover the biological and social sciences.

APPLIED GEOPHYSICS. In the Search for Minerals. By the late A. S. Eve and D. A. Keys. Cambridge University Press, 32 East 57th Street, New York 22, N.Y., fourth edition, 1954. 382 pages, 8¼ by 5½ inches bound. $7.50. An introductory textbook which combines the theoretical and practical approach in dealing with magnetic, electrical, electromagnetic, gravitational, seismic, and radioactive methods of exploration. Various well-logging methods are discussed in a separate chapter. Recent developments which have occurred since publication of the previous edition in 1938 are taken into account, and new material is included on aerial survey instruments, gravimeters, seismic reflection, and methods of locating radioactive ores.

AUTOMATIC CONTROL BIBLIOGRAPHY. By Warren F. Wade and Emory N. Kemler. Summary Reports. P. O. Box 176, Spring Park, Minn., 1955. 331 pages, 9 by 7 inches, bound. $15. This bibliography lists alphabetically by authors, 1,600 British and American periodical references, 1900–1954, most of them briefly annotated. In a partial attempt to classify the articles, lists by applications and areas of interest (e.g. automation, control panels, paper industry) are given following the alphabetical section. A bibliography of 120 books, of which a few are in French and a few in German, and a list of periodicals in the field are also included.

DYNAMICAL THEORY OF CRYSTAL LATTICES. By Max Born and Kun Huang. Oxford University Press, 114 Fifth Avenue, New York 11, N.Y., 1954. 420 pages, 9½ by 6¼ inches, bound. $8. The first part of this treatise consists of three chapters on atomic forces, lattice vibrations, and elasticity and stability, prepared by Dr. Huang as introductory material of a more elementary character which leads gradually to the more difficult general theory of the second half of the book. The second part presents the theoretical work of Professor Born in four chapters covering the quantum mechanical foundation, the method of long waves, free energy, and optical effects.

ELECTRONIC MEASURING INSTRUMENTS. By E. H. W. Banner. Chapman and Hall Ltd., London, England, 1954. 395 pages, 9 by 6 inches, bound. 45s. The major part of this book deals with electronic devices used in measuring instruments—the cathode-ray tube, rectifiers, radiation detectors, etc.—and with specific instruments using these devices. The last-named include instruments in which the tube is the device making measurement possible, photoelectric instruments, the radiation thickness gauge, and others. A separate section is devoted to instruments containing some electronic element; the resistance strain-gauge, transducers, magnetic amplifiers, and so on. Indicating instruments are discussed briefly in the first chapter.

ENGINEERING UNITS AND THE STROUD CONVENTION. By F. W. Thorne and A. C. Walshaw. Blackie and Son Ltd., Glasgow, Scotland, 1954. 99 pages, 8½ by 5½ inches, paper. 3s.6d. The Stroud convention is a method of simple analysis which utilizes standard symbols representing physical quantities to form physical formulas or equations; then by replacing each symbol by a number multiplied by a proper unit in dealing with the arithmetical stage a numerical solution is obtainable. The further use of "unity brackets" (simple conversion forms) allows mixtures of units to be reduced to a consistent system.

ERWÄRMUNG UND KÜHLUNG ELEKTRISCHER MASCHINEN. By Gottfried Gotter. Springer-Verlag, Berlin, Germany, 1954. 328 pages, 9½ by 6½ inches, bound. DM 34.50. Intended for practicing electrical engineers as well as for advanced students, this text deals with the heating and cooling of electric machinery. After considering the fundamentals of heat transfer, the book takes up the following: 1-dimensional problems; time-variable processes; effect of heat on materials, operation, and individual elements; thermal calculations of transformers; cooling of rotary machines; practical hints on testing.

FALK'S GRAPHICAL SOLUTIONS TO 100,000 PRACTICAL PROBLEMS. Prepared and edited by Karl H. Falk. Columbia Graphs, Columbia, Conn., fourth edition, 1954. 419 pages, 8½ by 5½ inches, bound. $6. A compilation of 400 worked-out graphs covering standard calculations for a wide range of practical problems in mechanics, hydraulics, physics, chemistry, shop work, construction, electricity, weights and measures, and other fields. In this edition, workable formulas accompany many of the graphs, which are of the simple type giving the solution at the intersection of two lines traced from the known quantities.

HUMAN LIMBS AND THEIR SUBSTITUTES. Edited by Paul E. Klopsteg, Philip D. Wilson, and others. Sponsored by Advisory Committee on Artificial Limbs, National Research Council. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N.Y., 1954. 844 pages, 9½ by 6½ inches, bound. $12. Twenty-five medical and engineering studies in the field of modern prosthetics are published in this volume under four broad groupings: medical problems of the amputee, the upper limb and its substitutes, the lower limb and its substitutes, and adjustment of the limb to the amputee. Of particular interest to engineers are studies dealing with biomechanics of limbs, design of hands and hooks, materials for artificial limbs, controls and power sources for the electric arm, and others. References are listed after each chapter.

THE DILWORTH STORY. By Franklin M. Beck. McGraw-Hill Book Company, 330 West 42d Street, New York 36, N.Y., 1954. 105 pages, 8¼ by 5½ inches, bound. $3. An informal biography, which in addition to describing Dilworth's work at the Electro-Motive Division of General Motors in developing the first successful diesel-electric passenger locomotive, records his contributions to a number of other technological innovations. These include the first experimental diesel engine constructed in the United States, the gas-electric rail car, and the distillate-burning engine.

INTRODUCTION TO U.H.F. CIRCUITS AND COMPONENTS. By Milton S. Kiver. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N.Y., 1955. 408 pages, 9½ by 6 inches, bound. $7.50. A simplified presentation of interest to those concerned with the production, installation, and maintenance of uhf equipment; this book covers specific components—transmission lines, waveguides, and cavity resonators; methods of generating higher frequencies, including oscillators, the resonatron, and traveling-wave tubes; antennas; uhf measurements; and radio and television receivers. An introductory chapter discusses the changes necessary in adapting familiar tuning circuits to higher frequencies.

KEMPE'S ENGINEER'S YEAR-BOOK FOR 1955. Edited by C. E. Prockter. Morgan Brothers, Ltd., London, England, 60th edition, 1955. Two volumes, 7 by 5 inches, bound. 75s/2 vol. Although revisions in the present edition of this comprehensive handbook are chiefly confined to details, some additional information is included on shell molding, geared couplings, and the preparation of rolls. New material has also been added to chapters on electronic engineering, flow metering, and explosives.

MAGNETIC AMPLIFIERS. By H. F. Storm. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N.Y., 1955. 545 pages, 9½ by 6 inches, bound. $13.50. Directed to practicing engineers and advanced students, this book explains the fundamentals underlying the operation of static (nonrotating) magnetic amplifiers and illustrates their chief uses. The major part of the book is the discussion of theory, limited to single-phase operation and dealing with the whole range of amplifiers from the ordinary saturable reactor to the saturable-reactor circuit with blocked intrinsic feedback. Magnetic materials and testing are also fully discussed. A separate section is devoted to components, and six chapters cover a wide variety of uses of different types of amplifiers. An extensive bibliography is included.

MODERN ASPECTS OF ELECTROCHEMISTRY. Edited by J. O'M. Bockris. Academic Press, Inc., 125 East 23d Street, New York 10, N.Y., 1954. 344 pages, 8¼ by 5½ inches, bound. $6.80. Five selected topics in fields in which recent significant advances have been made are treated in this volume. Three of the chapters are chiefly devoted to a balanced summary of existing knowledge. These cover the physical chemistry of synthetic polyelectrolytes, electrode kinetics, and electrochemical properties of nerve and muscle. The remaining chapters—on ionic solvation and equilibrium properties of electrified interphases—are critical discussions covering recent advances, but also suggesting areas where new advances are urgently needed.

MULTIPOLE FIELDS. By M. E. Rose. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N.Y., 1955. 99 pages, 9½ by 6 inches, bound. $4.95. In this small volume the theory of angular momentum and some recent applicable developments in the algebra of irreducible tensors are employed in the description of the electromagnetic field. The first three chapters develop the theory of multipole fields, the last three apply it to a few problems in nuclear physics: retarded electromagnetic interaction, internal conversion, and emission of gamma radiation. A general knowledge of quantum mechanics and electromagnetic theory is assumed.

NATIONAL ELECTRONICS CONFERENCE, PROCEEDINGS. Volume 10, 1954. National Electronics Conference, Inc., 84 East Randolph Street, Chicago, Ill., 1955. 808 pages, 9½ by 6¼ inches, bound. $5.00. Eighty-six technical papers on magnetic amplifiers, servomechanisms, microwaves, circuit theory, and a wide range of subjects in the field are included. A special feature of this year's volume is a cumulative index covering volumes 1 to 10.

PHYSICS: A DESCRIPTIVE INTERPRETATION. By C. H. Bachman. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N.Y., 1955. 497 pages, 8½ by 5½ inches, bound. $5.50. This book has been designed to present to nonscience students a well-rounded up-to-date well-illustrated readable account of the subject, and to encourage them to recognize and understand physical principles in things about them. In the first part of the book the author discusses basic concepts; the electromagnetic spectrum; particle physics; the classical branches; earth physics; and astrophysics. In the second part physical principles are applied to the understanding of the human body—vision, body mechanics, etc.—and to selected engineering problems. The author's method is descriptive, without recourse to mathematics.

DIE PRÜFUNG DER ELEKTRIZITÄTSZÄHLER. By Karl Schmiedel. Springer-Verlag, Berlin, Germany, fourth edition, 1954. 234 pages, 9½ by 6¼ inches, bound. DM24.50. This manual on electric meter testing provides a comprehensive survey of the important methods and equipment. Assuming a knowledge of fundamentals of electrical engineering and electric meters, the book includes discussion of limits of error and their determination, current sources and regulators, compensators, meter relay circuits, stroboscope equipment, and monitoring circuits.

STAUANLAGEN UND WASSERKRAFTWERKE. Part III: Wasserkraftwerke. By Heinrich Press. Wilhelm Ernst and Sohn, Berlin, Germany, 1954. 340 pages, 9½ by 6¾ inches, paper. DM35.00. The design, construction, and operation of hydroelectric power plants are dealt with in this third volume of a series on dams and power plants. It covers structural details, turbines, and auxiliary installations—both high and low head, and methods of calculation of waterhammer, head losses etc. Underground and submerged plants are included.

TRANSISTORS: THEORY AND APPLICATIONS. By Abraham Coblenz and Harry L. Owens. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N.Y., first edition, 1955. 313 pages, 9½ by 6¼ inches, bound. $6. The basis of this volume is a series of articles published in *Electronics*, March 1953–January 1954, now considerably revised and expanded for book publication. In its present form it provides an essentially practical treatment of transistors, showing principles of operation, how they are made, and how they are applied in electronic circuits. Theory is presented with a minimum of mathematics and with emphasis on applications, and information is included on manufacturing process, testing, and use of both silicon and germanium transistors. Chapter bibliographies are provided.

VIBRATION PROBLEMS IN ENGINEERING. By S. Timoshenko. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N.Y., third edition, 1955. 468 pages, 9½ by 6 inches, bound. $8.75. This standard work on fundamentals and applications of vibration theory has been thoroughly revised to incorporate important new developments. The first chapter, on systems having one degree of freedom, has been thoroughly recast; the chapter on nonlinear vibrations has been expanded to include new methods of treatment; and the chapter covering elastic bodies has been completely revised. In the last, new topics, such as combined bending and torsional vibrations of beams, are discussed. The appendix, dealing with measuring instruments, has been omitted from this edition.

YAGI-UDA ANTENNA. By Shintaro Uda and Yasuto Mushiake. Research Institute of Electrical Communication, Tohoku University, Sendai, Japan (available from Maruzen Company, Ltd., P. O. Box 605 Tokyo Central, Tokyo, Japan) 1954. 183 pages, 8½ by 6 inches, bound. $4. In developing the general theory of this vhf-uhf antenna in the first part of this study, the authors deal with linear antennas, input impedances of two parallel antennas, and the theory of an

antenna with discontinuous thickness. Later chapters treat in detail the design of 2- and 3-element antennas, the folded antenna, and a number of related problems. Practical examples of Yagi-Uda antennas are described.

AUTOMATIC FEEDBACK CONTROL SYSTEM SYNTHESIS. By John G. Truxal. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1955. 675 pages, 9¼ by 6¼ inches, bound. $12.50. Intended as a text for a graduate course in servomechanisms and as a reference book for engineers in industry, this book reviews the elements of Laplace transform and complex function theory and treats in detail basic concepts of feedback theory; design in terms of the Laplace transforms; statistical design fundamentals and applications; and the analysis of nonlinear feedback systems. Although the main emphasis is on theory, some practical examples are used to illustrate the discussion.

AUTOMATIC PROTECTION OF A.C. CIRCUITS. By G. W. Stubbings. Revised and edited by C. M. Dobson. Chapman and Hall, Ltd., London, England, fourth edition, 1954. 355 pages, 8¾ by 5⅝ inches, bound. 50s. This study deals with the theory of protective transformers, with their characteristics under normal and fault conditions, and with their interconnection in the various ways required for automatic protection. It also treats the theory, construction, and operating characteristics of protective relays, and the assembly of transformers and relays for the protection of electric machinery and cable networks. A separate chapter is devoted to testing and maintenance of equipment.

BETRIEB UND ANWENDUNG VON LEISTUNGS- UND REGELTRANSFORMATOREN. By Fritz André. Springer-Verlag, Berlin, Germany, 1954. 319 pages 9¼ by 6¼ inches, bound. DM33.00. A treatise on the operation and application of power and regulating transformers, designed to provide engineers with the necessary information for the proper selection and operation of modern equipment. Detailed sketches and graphs accompany the descriptive treatment of the various types.

THE BOMB, SURVIVAL AND YOU. By Fred N. Severud and Anthony F. Merrill. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N.Y., 1954. 264 pages, 9¼ by 6 inches, bound. $5.95. The authors—a structural engineer and a journalist with first-hand experience with urban bombings in England—have attempted to bring together all pertinent information in a form that will be of interest to engineers, architects, civil defense workers, and laymen. They discuss characteristic effects of atom bombs; data from Hiroshima and Nagasaki; fire control; shelter construction; protection of machinery; strengthening existing structures; and design of bomb-resistant buildings. The design information included is of a general nature and will be supplemented by a second volume containing mathematical analyses of blast loadings.

ELECTROPLATING ENGINEERING HANDBOOK. Edited by A. Kenneth Graham. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N.Y., 1955. 650 pages, 10¼ by 7 inches, bound. $10.00. More than 40 experts have contributed to this comprehensive practical handbook for electroplaters, electroplating engineers, designers, manufacturers, and other users of electroplating. The first of the two parts of the book covers general processing information: tables of data on chemicals and metals; cleaning; electropolishing; water; wastes; metal surface treatments; design of parts; both compositions; etc. Part II deals with installations; including floors and foundations; tanks; linings; current sources; automatic plating machines; filtration; and other engineering and operating considerations. A glossary precedes the main text.

ELEKTROSTATIK IN DER TECHNIK. By Ulrich Neubert. R. Oldenbourg, Munich, Germany, second edition, 1954. 194 pages, 9¼ by 6 inches, paper. DM 19.80. This textbook on electrostatics in engineering summarizes and gives a systematic interpretation of the present knowledge of the subject. It covers fundamentals, testing equipment, both old and new types of electrostatic apparatus, and industrial applications. Actual installations are described in an appendix.

ELEMENTS OF POWER SYSTEM ANALYSIS. By William D. Stevenson, Jr. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N.Y., 1955. 370 pages, 9¼ by 6¼ inches, bound. $7.50. A text for senior electrical engineering students, covering parameters of electric transmission lines, fault calculations, transmission-line calculations in the steady state, and power system stability, particularly under transient conditions. A large number of examples showing the details of solution of varied types of problems are included.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Electrical Equipment You Can Build. Designed primarily for use in 4-H electric programs and other rural youth programs, this booklet has detailed plans for more than 50 pieces of equipment that can be built and used around the home or on the farm. The new booklet contains plans for indoor and outdoor lighting equipment, shop equipment, signal systems, and productive equipment for the farm ranging from simple brooders and electric hotbeds to a mechanical dairy feeder. Background information is included for each piece of equipment and drawings show materials needed and procedure to follow during construction. Many of the plans in the booklet have been adapted from plans suggested by extension service specialists and by power supplier representatives who work closely with 4-H Club boys and girls and other rural youth groups. 32 pages. Copies of this booklet (*B-6511*) are available to power suppliers for $4.50 per 100. Single copies will be mailed free of charge. Write to Westinghouse Farm Youth Activities, P. O. Box 2278, Pittsburgh 30, Pa.

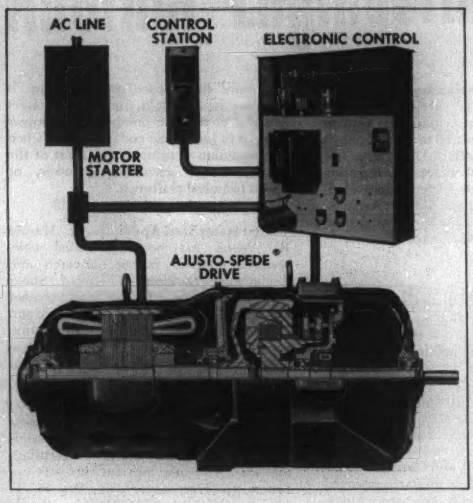
Abstracts of Theses. Publication of abstracts of the 174 theses accepted for the doctor's degree at the Massachusetts Institute of Technology (MIT) during the period between September 1952 and July 1953 has been announced by the MIT Office of Publications. Also listed are the titles of theses presented for engineer's and master's degrees in the academic year 1952–1953. Abstracts are included of theses presented in the departments of electrical engineering, aeronautical engineering, biology, chemical engineering, chemistry, civil and sanitary engineering, economics and social science, food technology, geology and geophysics, mathematics, mechanical engineering, metallurgy, meteorology, and physics. Microfilms or photoprints of each complete thesis text may be ordered from MIT by reference to the information given in the publication. Offset copies of the engineer's and master's theses are also available on a similar basis. 276 pages. $2.50. Copies of the 1952–1953 "Abstracts of Theses" publication are available from the MIT Office of Publications.

Calling All Jobs. "Automation," a word which often strikes fear in the heart of the factory employee, actually describes a machine age which is the worker's best friend, according to a report published by the National Association of Manufacturers (NAM). This booklet is designed to end such fears. Historical examples are used to show that every improvement of the machine age which has increased productivity has increased the total number of jobs, thus proving that automation is the friend of the worker rather than his enemy. The NAM study notes, for example, that General Motors' employment has risen 200,000 in the past few years in spite of all the new and modern automatic equipment installed. Quotes from the Ford Motor Company point out that "automation at Ford conserves manpower, but it does not eliminate men from the industrial scene; instead it saves men from many burdens and hazards and gives them jobs which utilize their brainpower more effectively." It is told, in layman's language, how some of the automatic gadgets, such as electronic brains and digital computers, are making the United States the most productive nation the world has ever known. Also, a new era of rapidly rising living standards, spurred by automation, is foreseen. 24 pages. Copies are 10¢ each up to 100. For quantity order, the price is reduced. Send to National Association of Manufacturers, 2 East 48th Street, New York 17, N. Y.

Engineers' Job Directory. This guide is specifically for the young engineer—to help him research the better job market. One hundred and twenty-nine participating companies have co-operated in presenting key facts in capsule form, giving precise information about their companies, industry, year founded, products, number of employees, and whom to contact. This enables the engineer to co-ordinate and match his interests and capabilities in getting the right job with the right firm. Participating companies include: Alcoa; American Steel and Wire Division, Babcock and Wilcox Company; Continental Can; Goodyear Tire and Rubber Company; International Business Machines; Minneapolis Regulator Company; National Cash Register Company; Pittsburgh Plate Glass Company; and Radio Corporation of America. Also included is a unique index section. Companies indicate the types of engineers they want—electrical, chemical, mechanical, etc. The index also lists the plant, sales, and research laboratory locations by cities and states. Another section lists the companies interested in undergraduates for summer jobs. This enables young engineers to gain experience with these companies. $2.25. Copies may be obtained from Decision, Inc., 105 East Fourth Street, Cincinnati 2, Ohio.

Professional Engineering Registration Laws. This is a compendium of registration laws for professional engineers in the 48 states, Alaska, Hawaii, Puerto Rico, and the District of Columbia. The book has been compiled by Alfred L. McCawley, attorney and former Missouri State Senator. The compendium is the culmination of an extensive research project undertaken by Mr. McCawley under the sponsorship of the National Society of Professional Engineers. The book presents, state by state, the exact legal requirements that must be met for professional practice. It is a reference volume designed for the professional engineer or the engineer-in-training who plans to practice on a permanent or part-time basis in another state or territory. Covered in detail are such elements of the state laws as temporary permits, fees and bonds, the filing of maps, certificate applications, education requirements, examinations, and public works projects. The laws are cited for reciprocity, registration renewals, corporate and partnership practice, revocation of registration, and violations and penalties. 614 pages. $8.75. The book may be ordered from the Trustee Publication Fund, Jefferson City, Mo.

SPEED CONTROL BY



DYNAMATIC®

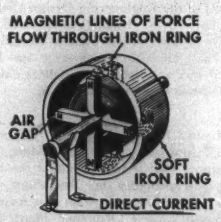
How it Works — What it Does — Why it's Better

Increased production, reduced costs, improved quality of product, and more complex processing techniques demand an ever increasing use of stepless adjustable speed drives. Dynamatic eddy-current equipment in one form or another attains these objectives.

Dynamatic Ajusto-Spede® Drives, Air and Liquid Cooled Couplings, Air and Liquid Cooled Brakes, Absorption, Motoring, and Universal Dynamometers operate on the same basic electro-magnetic principle.

A typical installation pictorially illustrates the simplicity and minimum components required to obtain controlled adjustable speed.

Basic Principles of Operation



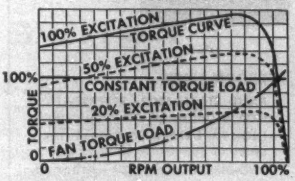
The transmitting of torque by Dynamatic eddy-current devices is based upon a simple magnetic principle easily demonstrated by the physics experiment, using a horseshoe magnet, iron filings, and a piece of cardboard. If several unmagnetized soft iron bars in the shape of a U, illustrated in the above drawing, are inserted in an insulated coil of wire, the bars will become magnets when direct current flows through the coil. Strength of the magnetic field is determined by the current flowing and the number of turns in the coil. By adding a solid ring of soft iron, encircling the poles of the electromagnets, the magnetic lines of force will flow through the ring. The basic construction of all Dynamatic eddy-current rotating equipment is then simulated.

The illustration shows magnetic lines of force with no relative rotation between the ring and magnets. When the field assembly (magnets and coil) is rotated mechanically, the iron ring separated from it by a nominal air gap remains stationary until current is applied to the coil. With the coil energized, mechanical rotation of the magnets produces movement of magnetic flux in the ring, creating eddy-currents in the ring. These induced currents develop a second magnetic field. Its strength is determined by the strength of the primary field and the relative speed difference (slip) between the two members. In the eddy-current coupling, attraction of these two fields cause the ring to follow the field magnets in rotation. When the coil current is varied, the eddy-currents will be proportionately affected, and torque produced at the output shaft will be similarly changed.

A typical eddy-current coupling torque curve with rated excitation and additional curves with reduced excitation is shown. In the same figure, a constant torque and fan torque load curve is plotted. Excess torque, which is a measure of accelerating capacity, is indicated. The Dynamatic coupling transmits this torque from a driving member, that may be either the drum ring or field magnets, to a driven member without mechanical contact.

Because of the extremely small excitation requirements, Dynamatic units lend themselves readily to electronic or magnetic amplifier control.

By taking advantage of the very high amplification factor of these controls, the largest couplings can be easily and conveniently controlled with a small adjusting potentiometer. The voltage output of a permanent magnet alternator mounted on the coupling output shaft varies directly with the shaft speed. This variable voltage signal modulates the control, automatically maintaining the selected speed of the coupling output shaft, within close limits, over a wide speed range.



Other features are easily incorporated—constant tension, controlled acceleration, threading, jogging or inching, torque limit, speed matching, and many others.

The relative simplicity, smoothness of operation, accuracy, ease of control and low maintenance of Dynamatic eddy-current equipment are factors meriting serious consideration of this type of equipment on almost all adjustable speed applications.

A free copy of the Dynamatic General Bulletin describing eddy-current equipment in more detail is available. Write for your copy.

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DataReader
Model 546

A transport unit for high speed searching, reading and recording of data on magnetic tape.

PERFORMANCE:

RAPID START—STOP—REVERSE—from stop to full speed in 6 milliseconds.
HIGH TAPE SPEED—optional single speed of 30, 40, 50, 60 or 75 in/sec.
TWO-DIRECTION SEARCH—either direction, automatically at full speed.
REMOTE OPERATION—forward, reverse, stop, rewind and selection of reading and writing.
VACUUM COLUMN TAPE CONTROL—provides strain-free tape feed over entire length of tape.
END-OF-TAPE SENSING—stops automatically at either end of tape.
RAPID REWIND—2400 ft. of ½" or ¾" tape in 3 minutes.

FOR FURTHER INFORMATION WRITE
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An Affiliate of
CONSOLIDATED ENGINEERING CORPORATION
OF PASADENA, CALIFORNIA
ElectroData Corporation maintains a nation-wide sales and service organization.

INDUSTRIAL NOTES ....

New Offices for Servomechanisms. Effective July 1, 1955, the executive offices of Servomechanisms, Inc., located at Garden City, N. Y., will be moved to the company's Eastern and Western Divisions. The move is a result of the increased integration by the two divisions. The Eastern Division is located at Post and Stewart Avenues, Westbury, N. Y., and the Western Division at 12500 Aviation Boulevard, Hawthorne, Calif.

RCA Completes Engineering Project. The Radio Corporation of America has announced completion of a new 5-building center that houses administration and engineering facilities for RCA consumer products and the RCA Service Company at Cherry Hill, N. J. The RCA Cherry Hill installation is located on a 58-acre tract between Haddonfield and Merchantville. The property is bounded by Route 38, Haddonfield Road, and Chapel Avenue. Approximately 1,400 persons are employed at Cherry Hill. The 2- and 3-story buildings house the executive, administrative, and engineering staffs of the RCA Victor Television Division, the RCA Victor Radio and "Victrola" Division, and the RCA Service Company, Inc.

Philco Forms New Division. To keep pace with the rapidly increasing demand for electron tubes and transistors, Philco Corporation has created a new division to be known as the Lansdale Tube and Transistor Company. William J. Peltz, formerly vice-president in charge of operations for the Television Division, has been named vice-president and general manager of the Lansdale Tube and Transistor Company.

General Electric News. Four new organization changes affecting managerial personnel of General Electric Lamp Division's sales districts have been announced. Jack M. Lime, manager of Buckeye Sales District, has been appointed retail sales manager for the large lamp department at Nela Park, Cleveland, Ohio. In his new position, Mr. Lime succeeds Theodore C. Ohart, who was transferred to Waterford, N. Y., to head marketing for the company's Silicone Products Division. George S. Trotter has been appointed the new manager of Buckeye Sales District. Theodore C. Lauck has been named to succeed Mr. Trotter as manager of Texas Gulf Sales District. Succeeding Mr. Lauck as manager of Delta Sales District is Gordon E. Brown.

General Electric plans to double the size of its new microwave research laboratory on Stanford University land at Palo Alto, Calif. Reason for the expansion stems from the rapid advances being made in the application of microwave electron tubes to the communications and radar industries. In addition to constructing 10,000 square feet more floor space, the company is doubling its leasehold from 3 to 6 acres and will double the number of employees from 70 to 140 by the end of the year when the expansion is completed. Most of the employees are scientists, engineers, or skilled technical craftsmen.

United States Steel Appointment. Harold R. Nelson has been appointed chief research engineer in the Research and Technology Division of United States Steel Corporation. In this newly created position, Mr. Nelson will supervise and co-ordinate research work in the application of automatic controls, instrumentation, and mechanization to steel processes.

Alcoa Promotions. Two new assistant directors of research and three new division chiefs have been appointed at the Aluminum Research Laboratories, New Kensington, Pa. The new assistant directors are Ernest C. Hartmann and Dr. P. T. Stroup. The elevation of these two men has been accompanied by the appointment of Harry N. Hill to succeed Mr. Hartmann as chief of the Engineering Design Division and Dr. A. S. Russell to replace Dr. Stroup as chief of the Process Metallurgy Division. Dr. L. M. Foster has been named successor to Dr. Russell as chief of the Physical Chemistry Division.

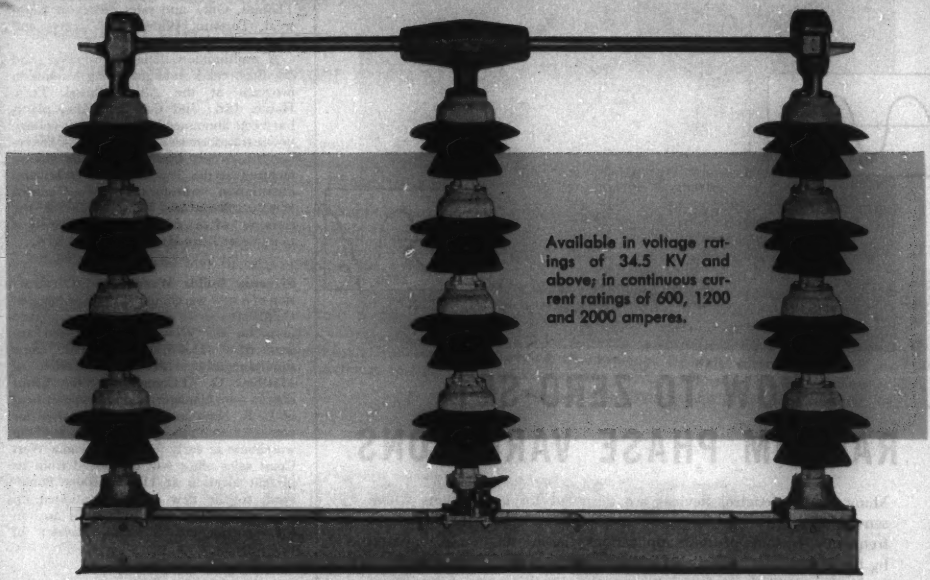
Raytheon Notes. Raytheon Manufacturing Company, Waltham, Mass., has announced that it will purchase the large plant and property in Tewksbury, and South Lowell, Mass., which was formerly the South Lowell Ordnance Plant, later occuped by Davis Aircraft Company. The plant's 210,000 square feet of production area have been converted to electronics manufacturing facilities, and have been operating as a Raytheon branch plant since 1952, under lease. Approximately 700 employees are engaged in government classified work there.

The opening of a new warehouse and sales office to speed the shipment of electronic tubes and related products to customers and dealers in the Midwest has been announced by the company from the headquarters of its receiving and cathode-ray tube operations, in Newton, Mass. The new structure is at 9501 Grand Avenue, Franklin Park, Ill., on the outskirts of Chicago.

Allis-Chalmers News. Election of Harold M. Schudt as president, Canadian Allis-Chalmers Limited, has been announced by the General Machinery Division, Allis-Chalmers Manufacturing Company. The General Machinery Division of the parent Allis-Chalmers Company is in charge of operations of Canadian Allis-Chalmers Limited. He replaces Mark C. Lowe who

(Continued on page 24A)

Another Engineering Achievement!



Available in voltage ratings of 34.5 KV and above; in continuous current ratings of 600, 1200 and 2000 amperes.

SOUTHERN STATES TYPE RDC DOUBLE SIDE BREAK SWITCH

One of the nation's largest utilities said: "Give us a double break switch with low radio interference voltage characteristics, high momentary current rating, and complete protection against icing and corrosive contaminants."

The new Southern States Type RDC is the answer—truly a triumph in engineering.

Here is a switch with high pressure silver-to-copper line contacts, a minimum number of current interchange points, shuntless design and wide angle blade rotation—plus Amplitact® contacts to provide the greatest dependability under high short circuit conditions. All mechanisms are shielded.

The Type RDC is a rugged, streamlined switch with smooth, corona-resistant contours that result in extremely low radio influence voltages. It is operated by rotation of the center insulator stack, with the blade rotating through a wide angle to open or close after entering the contacts.

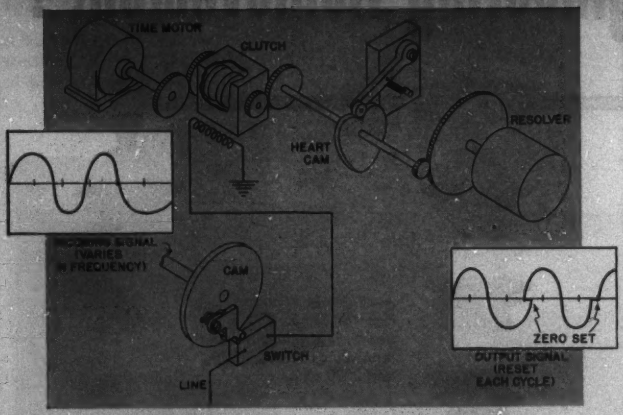
Here are other outstanding features of the Type RDC: greaseless, non-corrosive ball bearings support the switch blade; all force transmitting parts are made of high strength bronze; the switch blade is one continuous member from contact to contact.

Get your Southern States representative to give you more complete details about the new Type RDC double side break switch, or if you prefer, write direct for full information.

SOUTHERN STATES EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

SINCE 1915 LEADERS IN AUTOMATIC CONTROL



HOW TO ZERO-SET RANDOM PHASE VARIATIONS

Many modern control devices are designed for applications where sensed input signals fluctuate randomly about an approximately known frequency. In some of these applications, the information is conveyed by the phase relationship within one cycle, and the random cycle-to-cycle phase variations often submerge the signal in noise. Filtering, or averaging, techniques may be extremely difficult to devise because of the requirement for use within one cycle.

The ingenious electro-mechanical solution shown above is a typical Ford answer to a difficult problem. It is rugged and reliable, yet compact and easy to service. In operation, a constant-speed motor drives a resolver at the required speed. The sensed input controls the operation of the clutch, and at each zero-crossing in the positive direction, decouples the motor from the line. At the same time, the spring-loaded heart cam follower resets the synchro shaft to its zero position.

In this manner, the resolver is reset to a prescribed phase relative to the signal at a fixed point of every cycle of the generated signal.

This is another instance of how Ford's engineering staff selects the most efficient device to solve a problem. Here at Ford mechanical *and* electronic devices are given consideration in solving any problem.

Since 1915 the engineers at Ford Instrument Company have specialized in such equipment as computers, controls, and servo-mechanisms in hydraulics, electronics, mechanics and magnetics for the Armed Forces and for industry. If you have problems in any of these fields, it will pay you to discuss them with Ford engineers.

67

FORD INSTRUMENT COMPANY
DIVISION OF SPERRY RAND CORPORATION
31-10 Thomson Avenue, Long Island City 1, N. Y.

ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.

(*Continued from page 14A*)

resigned after being president of Canadian Allis-Chalmers Limited since 1951 and affiliated with the company since 1947. In his new capacity Mr. Schudt will be in charge of operations which include general offices in Lachine, Que., Canada, manufacturing plants at Lachine and St. Thomas, Ont., and sales offices in Montreal, Toronto, Winnipeg, Calgary, and Vancouver.

A multimillion dollar transformer and circuit breaker manufacturing expansion program at the Allis-Chalmers Terre Haute, Ind., and Gadsden, Ala., plants has been announced. Large high-voltage power transformers and high-voltage heavy-current circuit breakers will be manufactured at the Terre Haute Works, and distribution transformers at Gadsden Works. Plans are being made for the erection of a new 114,000-square-foot building at Terre Haute.

Sylvania Builds Warehouse. Construction of a new warehouse in the Los Angeles, Calif., area to service Sylvania cellophane users on the West Coast has been announced. This announcement came simultaneously with the promotion of Matthew G. O'Connor to West Coast district sales manager, and the appointment of L. E. Nash as sales representative for converter accounts. On completion of the warehouse in early fall, the Sylvania West Coast sales office will be moved from its present location at 1127 Wilshire Boulevard, to the new building, situated on Corsair Street in the Vail Field area of the central manufacturing district of Los Angeles.

Greist Aquisition. Air-Marine Motors, Inc., of Amityville, N. Y., and Los Angeles, Calif., has been acquired by The Greist Manufacturing Company of New Haven, Conn., through an exchange of stock. The new officers of Air-Marine Motors, Inc., will be David H. Thomas, president; Hubert M. Greist, executive vice-president; Merritt D. Vanderbilt, treasurer; John B. Wolff, Jr., vice-president and assistant treasurer; and Hector G. Dowd, secretary. There will be no other change in present operating personnel and policies of the company.

New Division to Manufacture Automation Equipment. G. M. Giannini and Company, Inc., has formed a division to be known as the Giannini Datex Division. The new autonomous division was formed in order to extend the automation activities of the Laboratory Apparatus Division. Activities will be expanded to include automatic control and data recording for industrial processes, and the conversion of data into digital form for use with digital computers.

Smith Named Head of AMF Atomics Inc. General Walter Bedell Smith has been named chairman of the board, and president of American Machine and Foundry (AMF) Atomics Inc. AMF Atomics Inc., is a wholly owned and newly

(*Continued on page 30A*)

MAGNECRIMP PRE-ROUNDS RECTANGULAR MAGNET WIRE . . . FOR COMPRESSION-INSTALLED CRIMPED TERMINALS.

Now you can reshape square or rectangular magnet wire to fit standard tubular compression connectors—and get stronger, more efficient joints—at lower cost!

BURNDY'S NEW COMPOUND DIE — *1.* Rounds conductor ends to fit standard round connector barrels—without reducing conductor size! *2.* Crimps joints with quad indent.

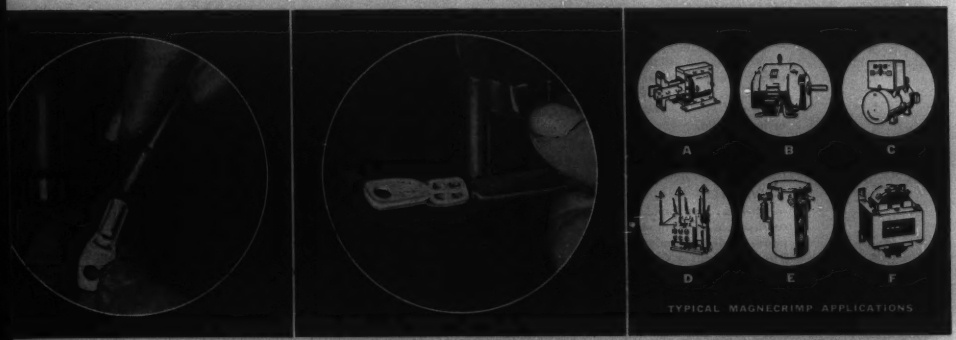
SMALLER, MORE ECONOMICAL LUGS — Rectangular conductor ends are reshaped to smallest possible diameter, without reducing cross-sectional area. This permits use of smaller crimped lugs to take minimum space, look better, cost less.

MAXIMUM ELECTRICAL EFFICIENCY — Pre-rounded wire, precisely shaped to matching lugs, insures best possible cross-section contact for high conductivity, eliminates potential corrosion spaces, provides maximum resistance to vibration.

STRENGTHENED JOINTS — Soft copper wire ends are work-hardened during rounding and crimping—*creating pullout strengths up to 90%.*

This revolutionary new Burndy *Magnecrimp* method and dies are ready to go to work for you — ready for fitting into your present Hypress. Simple conversion kits — in a complete range of die sizes — are now available. Or if you wish, a complete Hypress unit with compound rounding and terminating dies can be shipped to your order. Call your nearest Burndy representative for full details, with recommendations for your specific engineering requirements. Or write direct to BURNDY, Norwalk, Connect., Toronto, Canada. *Factories:* New York, Calif., Toronto. *Export:* Philips Export Company.

with MAGNECRIMP



3. Inserting rounded magnet wire in Hylug. Note how wire has been reshaped—not reduced in size.

4. Finished compression connection, work-hardened by pre-forming and quad indentation. Note neat installed appearance.

A. Solenoid **B.** Motor **C.** Generator **D.** Power Transformer **E.** Distribution Transformer **F.** Transformer

It's good business to connect with . . .

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. . . FIRST name in electrical connectors; tools; methods

Wet... but not worried!

Stoddart NM-10A Radio Interference and Field Intensity Meter*
covering the frequency range of 14 kc to 250 kc

CHANCES ARE YOU'LL NEVER SUBJECT YOUR NM-10A TO THIS KIND OF TREATMENT..

BUT IT'S NICE TO KNOW THAT IT CAN TAKE IT IF IT HAS TO! We turned the hose on the AN/URM-6B — the Navy equivalent of the Stoddart NM-10A — in accordance with Navy specifications. Immediately afterward it was disassembled and found to be dry as a bone inside. And much to our satisfaction, the Navy inspector smiled!

Whether you use this fine, rugged instrument for field intensity measurements of carrier current systems, Navy, maritime or other services... or for surveys of conducted or radiated interference, you'll find that the *NM-10A CAN TAKE IT*... whether in the lab or in the field.

A complete selection of accessories is available, expanding the utility of the NM-10A to make it one of the most versatile instruments you have ever used.

Write today for further information. Learn about the excellent sensitivity... the "hand calibrated" accuracy... the sturdy, dripproof construction, enabling use in driving rain or snow... the A. C. power supply that permits operation from 105 to 125 volts or 210 to 250 volts A. C., 50 to 1600 cps.

The NM-10A is the identical instrument we supply to the Navy as the AN/URM-6B, a Class One instrument, as shown in MIL-I-16910 (SHIPS). It was designed and is manufactured exclusively by Stoddart Aircraft Radio Co., Inc. When you buy the NM-10A you're getting a quality instrument that meets the rugged requirements of the U. S. Navy!

*** Stoddart RI-71 Meters Cover the Frequency Range of 14 kc to 1000 mc**

NM-20B — HF	NM-30A — VHF	NM-50A — UHF
15 kc to 25 mc. Commercial equivalent of AN/PRM-1A. Self-contained batteries. A.C. supply optional includes standard broadcast band, radio range, WWV and communications frequencies. Has BFO.	20 mc to 400 mc. Commercial equivalent of AN/URM-47. Frequency range includes FM and TV bands.	375 mc to 1000 mc. Commercial equivalent of AN/URM-17. Frequency range includes Citizens band and UHF TV band.

STODDART AIRCRAFT RADIO Co., Inc.
6644-B Santa Monica Blvd., Hollywood 38, California • Hollywood 1-9294

(*Continued from page 24A*)

formed subsidiary of AMF which will carry forward the company's activities in the atomic energy field. AMF plans to become the industrial department store for atomic energy equipment.

Kuljian Appointment. Hilton A. Levonian has been appointed vice-president in charge of consulting engineering of The Kuljian Corporation. With headquarters in the main office in Philadelphia, Pa., Mr. Levonian will cover activities of his department both in the United States and abroad.

New Name. Claude Neon, Inc., has announced a change in the corporate name to Dynamics Corporation of America. Conversion since 1945 of the company (originally a licensor of lighting processes) into producers of electric, electromechanical, and electronic equipment determined the change.

Changes in Syntron. Syntron Company of Homer City, Pa., has announced two appointments in their Selenium Rectifier Division. C. W. Ramaley, sales application engineer in selenium rectifiers for 3 years, has been named manager of the rectifier department. James Scott will replace Mr. Ramaley as sales application engineer.

Chem-Etched Organized. Chem-Etched Circuits, Inc., 121 South Cowen Street, Garrett, Ind., has been formed to design, develop, and manufacture etched circuits by the photoengraving method. George C. Weiss, Frankfort, Ky., is president of the newly formed organization. Other officers include Kenneth L. Grimes, vice-president; Bernard H. Barnett, secretary-treasurer; Kenneth L. Smith, sales manager; and James E. Wolfkiel, Sr., manager of research and development.

Square D Promotion. James F. Magin, vice-president and a director of the Square D Company, has been appointed general manager of the company's Industrial Controller Division. He has had administrative duties in the company's Milwaukee facility, and was assigned to sales and research engineering activities in other Square D plants, including those in Los Angeles and San Francisco, Calif.

NEW PRODUCTS • •

Light-Beam Galvanometer. A series of shock-resistant light-beam galvanometers of exceptional compactness, with sensitivities up to 0.105 microampere per millimeter division, has been developed by Howell Instrument Company, Fort Worth, Tex. They are available as

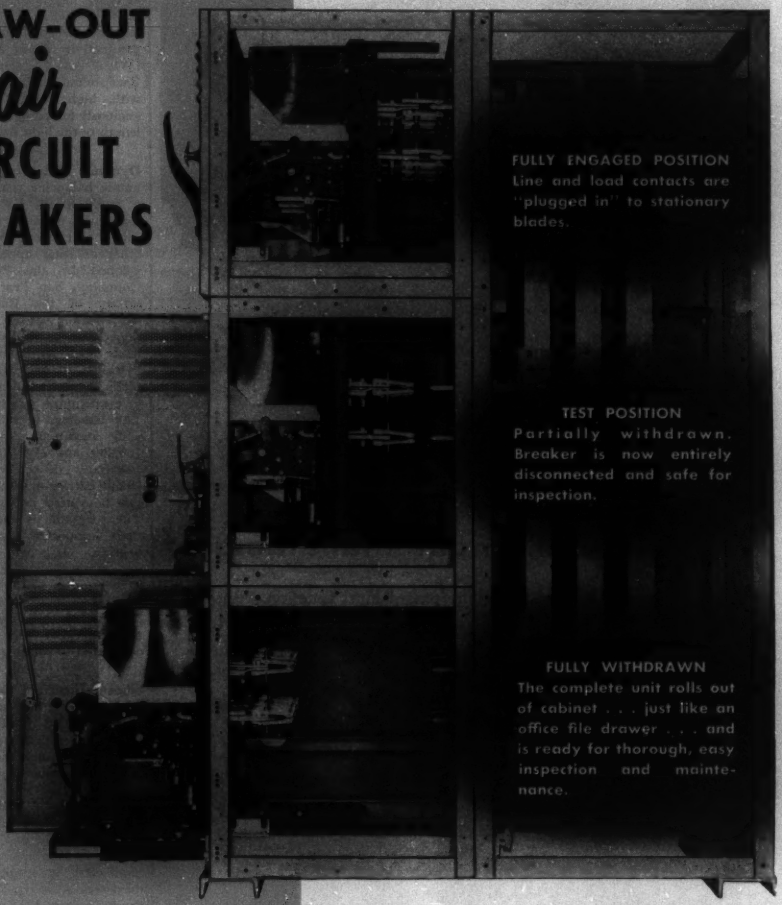
(*Continued on page 32A*)

3 STEPS TO SAFE EASY MAINTENANCE with

Roller-Smith

DRAW-OUT *air* CIRCUIT BREAKERS

"Reading" this picture from top to bottom, you'll see the three easy steps that make Roller-Smith Draw-Out Air Circuit Breakers so safe and simple to install, inspect and maintain. Illustrated, with enclosure side removed, are three 1600 ampere, 600 volt Draw-Out Air Circuit Breakers of 50,000 ampere interrupting capacity.



FULLY ENGAGED POSITION
Line and load contacts are "plugged in" to stationary blades.

TEST POSITION
Partially withdrawn. Breaker is now entirely disconnected and safe for inspection.

FULLY WITHDRAWN
The complete unit rolls out of cabinet . . . just like an office file drawer . . . and is ready for thorough, easy inspection and maintenance.

Roller-Smith

CORPORATION
ELECTRICAL SWITCHGEAR
BETHLEHEM, PENNSYLVANIA

Also available are electrically operated air circuit breakers. In their "test" position, auxiliary contacts remain in circuit to permit operation while line and load contacts are disconnected from stationary blades.

"See A Qualified Electrical Contractor"

AVAILABLE THROUGH
AUTHORIZED ELECTRICAL WHOLESALERS

Sales Representatives in all principal cities.
CANADIAN FOREIGN

built SPECIALLY for the *original equipment manufacturer

Each component part of **your** equipment must function without failure. One of the most important of these integral parts is the transformer. Standard O.E.M. Transformers are noted for their accuracy, dependability, compactness and sound basic construction. They're engineered especially for O.E.M. use. Many well-known original equipment manufacturers have specified O.E.M. Transformers for over 30 years. You can have Standard O.E.M. Transformers tagged for you, too! Consult your nearby Standard representative or write to Standard direct for specific information, literature or engineering consultation.

Standard
THE STANDARD TRANSFORMER COMPANY

WARREN, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

(*Continued from page 30A*)

completely housed galvanometer assemblies, with lamp and projection system included, ready for installation and use. Originally developed to withstand the extremely severe conditions of shock and vibration encountered in field servicing and testing of jet aircraft, the galvanometer is particularly suited to field work as well as for laboratory and industrial production testing services. Separately, the movement may be installed as an integral part of other industrial instrumentation in the fields of colorimetry and densitometry, or for measurement of electric potentials, conductivity, light flux, or temperature (Wheatstone bridge or thermocouple). Exceptional compactness is achieved, along with high sensitivity, through an ingeniously folded light beam. The effective length of the light beam is 80 millimeters.

Dynamic Balancing Machine. A dynamic balancing machine which provides a ready means for accurately detecting static and dynamic unbalance in a wide range of runners, rotors, flywheels, and other rotating apparatus, has been developed by the Pelton Water Wheel Company, San Francisco, Calif., a subsidiary of the Baldwin-Lima-Hamilton Corporation. It is a compact self-contained inexpensive unit which especially lends itself to balancing large-diameter flywheels, large and heavy hydraulic turbine rotating elements, or pieces up to a maximum weight of 250,000 pounds. The balancer is available in three sizes with maximum capacities of 10,000, 100,000, and 250,000 pounds. It consists essentially of a heavy support frame which carries a turntable whose rotation can be varied between 10 and 20 rpm. The turntable is carried on a weighing shaft supported by heavy antifriction bearings. It is held in a horizontal plane until static or dynamic forces tend to move it to another plane, and is restrained by the leaf springs. A direct measure of the dynamic out-of-balance is obtained by the magnitude of the indication properly correlated to rotating speed.

Silicone-Insulated Current Transformer. A new 5-kv current transformer (type *SM-5*) molded in silicone is designed for indoor metering and relaying applications, and is built in standard current ratings from 10 to 800 amperes. The transformer has a rating factor of 1.5 and is in the 0.3 accuracy class for all metering burdens. The new silicone-base insulating material is molded to the coil assembly, completely sealing it from moisture and air, and is unaffected by temperature change. Primary terminals are silver plated and added flexibility in making connections is possible through use of a slotted bolt hole. A 3-purpose secondary short-circuiting device can be operated automatically or manually. For further information, write Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, Pa.

All-Silicone Rubber Insulation. Allis-Chalmers Manufacturing Company, Mil-

(*Continued on page 36A*)

announces . . .

the Type 44 Recorder

designed specifically to do what you asked for*

YOU ASKED FOR:

New Performance Standards

FACT—Type 44 Recorder has new, iron-core measuring mechanisms which develop twice the torque of previous designs. This provides faster response, higher fidelity under all operating and load conditions.

Ease of Use and Service

FACT—all parts fully accessible from front of recorder, a particular advantage in flush switchboard mounting.

Less Mounting Space

FACT—recorder has highest ratio of scale width to panel area, is attractive in appearance.

Dependability

FACT—extremely high overload capacity reduces danger of burnouts, promotes longer life. All mechanisms self-shielded against stray magnetic fields.

Economy

FACT—long charts and large ink capacity permit operation for greater unattended periods.

Increased Availability

FACT—carefully coordinated, flexible design permits use of a few basic mechanisms for most applications. These are kept in stock to facilitate prompt delivery. Three kinds . . . flush mounted, projection mounted, or portable . . . available to handle watts, vars, a-c voltage and current, d-c voltage and current, frequency and power factor.

FOR MORE FACTS: CALL *The Man With The Facts* . . . your Westinghouse sales engineer. Or, get your copy of the facts booklet, B-5779, by writing directly to Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

*As determined by a user survey of engineers and operating men in all industries.

J-40479

YOU CAN BE SURE . . . IF IT'S Westinghouse

Reliable Recording—high-torque mechanism designs assure accurate, dependable recording. Performance is well within the requirements of ASA Specification No. C 39.2 for recording instruments of the 1% accuracy class.

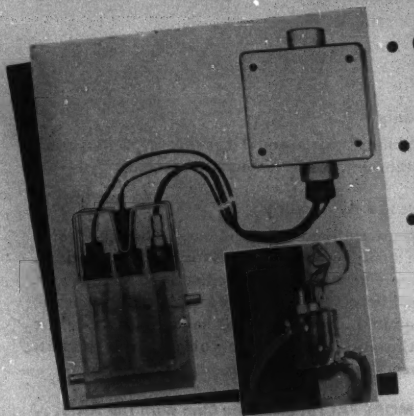
Convenient—all parts fully accessible from front of recorder, a distinct advantage in flush switchboard mounting. All moving elements are of unit construction, can be removed without disturbing the field circuit.

Protection—extremely high overload capacity is designed into these instruments. For example, improved insulation, conductors, and connections make it possible for the a-c current circuits to carry 100 times rated current for short overloads.

Leeds & Northrup Company
ELECTRODE ASSEMBLY FLOW BLOCKS

are made from

HYSOL 6000 Series
• EPOXIDE RESINS •
Because of these outstanding properties



- ONE-PIECE LEAKPROOF CONSTRUCTION
- RESISTANCE TO MANY CHEMICALS
- RESISTANCE TO ELECTRICAL PICK-UP
- MECHANICAL STRENGTH

The Leeds & Northrup "plastic flow type" electrode assembly above shows the flow block, at left, formulated from HYSOL 6000. Measuring about 4½" by 1½", it has three wells into which the pH electrodes and temperature compensator screw against sealing gaskets. Leadwires from these detecting elements are connected, in the terminal box at top, to leadwires from recording and/or controlling equipment. Insert shows the assembly in operation. The test solution flows through the block, under pressures up to 30 psi, where its pH is continuously detected by the electrodes.

HYSOL 6000 Series epoxide compounds provide the best plastic for this electrode assembly for many reasons. The block itself is produced from a single piece of plastic material. This one-piece construction provides great mechanical strength and prevents solution leakage. The fact that the flow block is chemically resistant is important, since measured solutions are either highly acidic or highly caustic. The d-c electrical insulating properties of HYSOL 6000 Series epoxide compounds minimize electrical pickup and current leakage which would create a measuring error.

PROGRESSIVE PRODUCTS — HYSOL — Product of HOUGHTON LABORATORIES, INC. — THROUGH CHEMICAL RESEARCH

Perhaps this use of HYSOL 6000 suggests a possible application for you. The HYSOL 6000 Series includes a complete line of room temperature and heat curing potting and casting compounds, easily machined sheets, rods and tubes and coating and laminating varnishes.

The skilled, experienced experts in our research, design and production departments are ready to serve you. Your inquiries will be answered at no obligation. Put Houghton Laboratories, Inc., products and personnel to work solving your plastic problems. Write, wire or phone today.

houghton laboratories, inc.

105 BUSH STREET, OLEAN, NEW YORK

(*Continued from page 32A*)

waukee, Wis., has announced the first all-silicone-rubber insulating system for large motors and generators. Known as the Silco-Flex system, it is immediately available for all class *H* insulated form-wound coils and for class *A* and *B* windings operating under certain service conditions. Using as its basic material Dow-Corning's Silastic silicone rubber, Silco-Flex insulation makes available the advantages known to be inherent in silicone base insulations. While all silicone insulations possess outstanding thermal endurance and moisture resistance, silicone rubber, in addition, has the flexibility and resilience formerly obtainable only in organic rubber. In the manufacture of Silco-Flex insulated stator coils, silicone rubber is applied to conductors, and vulcanized into a homogeneous mass by the application of carefully controlled heat and pressure. The result is a sealed, impervious dielectric barrier, continuous around the coil and leads, which forms a flexible, moisture- and heat-resistant wall over the entire coil structure.

Field Intensity Receiver. A field intensity receiver, model *R*, covering the microwave range 950 to 11,260 mc with four interchangeable plug-in r-f tuning units, has been announced by Polarad Electronics Corporation, Long Island City, N. Y. It features single-dial frequency control with a direct reading dial, along with double-tuned r-f preselection, and automatic frequency control. Model *R* will receive amplitude and frequency modulation and pulse. It reads directly in decibels and provides separate audio and video outputs. Also, provision is made for external metering and recording, as well as connectors for external i-f attenuators.

FM Radiotelephone. A new FM radiotelephone, designed especially for vhf radio communication in shipboard service, has been announced by the Marine Division of Mackay Radio and Telegraph Company, Inc., a subsidiary of American Cable and Radio Corporation. The new radiotelephone (Mackay type *215-A*) is adaptable for use on all types of small craft as well as ocean-going vessels. It provides five 2-way crystal-controlled channels that may be preset within any 1.1-mc band between 152 and 165 mc. A single compact dripproof cabinet houses the transmitter, receiver, and power supply. The associated control unit incorporates a permanent-magnet loudspeaker, all operating controls, and a telephone-type handset. The radiotelephone incorporates a double-conversion superheterodyne receiver circuit, which assures high sensitivity and selectivity. Cascade *M*-derived filters are employed in the receiver's second i-f amplifier to provide a high degree of adjacent band rejection.

Small-Size Oscilloscope. Availability of a new lightweight 3-inch portable oscilloscope is announced by the Hickok Electrical Instrument Company, Cleveland,

(*Continued on page 44A*)

CLASSIFIED BIBLIOGRAPHY ON INSULATED CONDUCTORS

Special Publication S-73

NEW
A New Approach
A New Philosophy

CONVENIENT
For Quick Reference
Easier to Read than a Log Table

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For complete description of this new system for referencing technical data, see Electrical Engineering, July 1955, page 567.

Price: $1.00
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P. O. Box 128

Hastings-on-Hudson 6, New York

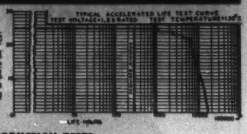
Further Proof of

Getting to the bottom of things

. . . is most clearly demonstrated by what we are doing every hour of every day — year in and year out — to make a finer fixed CAPACITOR.

One of the many things you as users are interested in is the "LIFE OF THE CAPACITOR" under a multitude of operating conditions. We in the FAST organization have spared no expense to give you honest-to-goodness answers on this important factor in providing quality capacitors.

What follows is a summary of what we are doing to give you just that . . .



I: RESEARCH and DEVELOPMENT TESTS

AC and DC tests at various temperatures and voltages.

1—Investigation of Impregnants: (a) New impregnants AC/DC—synthetic and natural oils, resins and waxes. (b) Studies of impurities and additives.

2—Investigation of electrode separators and electrode materials: (a) Kraft papers—standard, low PF varieties, sundry densities and deionized. (b) Films — regenerated cellulose, polystyrene, teflon, "Mylar"*, Etc. (c) Electrodes — Dry annealed and neutral aluminum; and tin.

3—Number of groups tested: AC; over 800 involving more than 8000 units. DC; over 3700 involving more than 78,000 units.

4—Duration of tests: AC; many have been continuously under test for over 6 years. DC; many have been continuously under test for over 10 years.

5—Voltage range of tests: AC; 70 to 2400 volts at 60 and 400 cycles. DC; 140 to 44,000 volts.

6—Temperature range of tests: AC; Room to 130°C. DC;—55°C to +150°C.

II: PRODUCTION TESTS

A. Alternating Current

1—Heat runs on production lots — ultimate surface temperature rise.

2—Ultimate life hours of current production (periodic tests run).

B. Direct Current

1—Civilian Production: (a) ultimate life hours of capacitors taken from current production. (These test runs comprise over 1800 groups involving more than 21,000 units).
(b) Ultimate life hours of capacitors after being stored in cartons from 1 to 24 months under normal variations in humidity and temperature. (These test runs comprise over 324 groups involving more than 3240 units).

2—Military Production: (a) Test to applicable specifications (Mil-C-25; Mil-C-91; U. S. Army 71-1667; Etc).
(b) These test runs comprise over 4200 groups involving more than 24,500 capacitors.

Please note Carefully: at least 75% of the 134,740 capacitors included in the above tests were tested to ultimate destruction at voltages ranging from rated to 4 times rated and at operating temperatures from lower than, to maximum rated or in excess of. Many outside this group have not failed to date. Importantly too, this is a continuous policy of the company in sustaining its testing program throughout every day—year after year.

So, with pardonable pride, may we suggest "QUALITY CAPACITORS" is more than a catch-phrase as applied to FAST CAPACITORS?

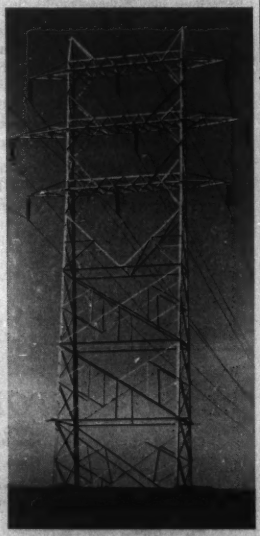
JOHN E. FAST & CO.
Capacitor Specialists For Over A Third of A Century
3169 North Pulaski Road, Chicago 41, Ill.
"WHEN YOU THINK OF CAPACITORS . . . THINK FAST"

**Du Pont trade-mark for Polyester Film.*

FLINT

developed
designed
detailed
fabricated

this unique Triple-Circuit Tower



The *completely integrated* service offered by Flint made this unusual tower possible. From original idea to actual erection, Flint was there. When you build *anything* with galvanized structural steel why not take advantage of this unusually complete Flint service.

FLINT STEEL

TULSA
MEMPHIS

THE *true* STORY of INFRA-RED RIDING HOOD

This is the real low-down. Contrary to the stories about the fateful day I hiked to Grandma's place—the wolf didn't pull the wool over my eyes! Before he knew what was happening, I had him spotted with my SERVOTHERM* system.

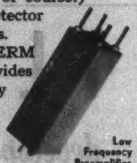
Man, is that a batch of instruments! They measure temperature where no contact is possible. My SERVOTHERM system measured the wolf's temperature and differentiated it from the ambient. Those SERVOFRAX glass lenses are real fast—the only glass that will pass the long wave lengths.

Infrared Lenses and Windows

Behind my SERVOFRAX window, I had a SERVOTHERM cell (type 1312, of course!) because it's a fast, sensitive infra-red detector with a time constant less than .005 seconds.

Thermistor Heat Cells Types 1312

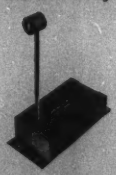
For a preamp, I used the finest—SERVOTHERM Model 1322 low frequency pre-amplifier that provides high gain and high impedance output. This baby is small enough to put in your vest pocket and is terrific for initial amplification for sub-audio and audio frequency signals from extremely low input levels.



Low Frequency Preamplifier

So . . . take a tip from a gal who knows—get on the ball with SERVOTHERM systems and keep the wolf away from *your* door!

*t.m.



Detector Preamplifier Model 1321

Thermistor Power Unit Model 1330

SERVO CORPORATION of AMERICA

New Hyde Park
Long Island, N.Y.

SERVO CORPORATION OF AMERICA
New Hyde Park, Long Island, N.Y. EG7

Please send further information and details on the following:

☐ Low Freq. Preamp. #1322 ☐ Detector Preamp. #1321
☐ Thermistor Power Unit #1330 ☐ Infrared Lenses & Windows
☐ Thermistor Heat Cells, Types 1312, 1317, 1340

Name_____
Position_____
Company Name_____
Company Address_____
City_____ Zone____ State_____

(*Continued from page 36A*)

Ohio. Similar to equipment manufactured for the Armed Forces, it features a new 6-section unitized circuit construction for minimum interaction between amplifiers and sweeps, and provides for replaceable circuit sections as individual units. Slightly larger than a normal-sized telephone, the model *385* provides a new high in dependable accuracy to both laboratory technicians and field engineers. It is available as a portable, portable with moisture-proof carrying case, or as a rack mount.

TRADE LITERATURE

Lighting for Industry. The newly enlarged edition of "Lighting for Industry," a 112-page handbook published by Holophane Company, Inc., 342 Madison Avenue, New York 17, N. Y., is available. The first 20 pages are devoted to general engineering information on principles and economics of lighting. The rest of the book offers lighting solutions in specific industrial areas, divided into indoor and outdoor areas. Each lighting problem is explained in terms of fundamental principles, actual equipment needed, and most advantageous applications. Every subject is illustrated; more than 120 technical diagrams, sketches, charts, and installation photographs show Holophane equipment in use. Throughout, there is emphasis on long-term economy as a basic function of engineering efficiency.

Hydraulic Turbines. Bulletin *1001*, recently published by Baldwin-Lima-Hamilton Corporation, Philadelphia, Pa., illustrates the company's hydraulic turbine research facilities and describes different types of hydraulic turbines and associated equipment which have been built for various hydroelectric projects. The 22-page booklet also contains approximate equations which can be used as a general guide in preliminary selection of turbine speeds and sizes for application to given conditions of head and horsepower, or turbine discharge. Also included is a list of suggested data to furnish the supplier when requesting turbine proposals.

Tube Types. A new edition of "Essential Characteristics," General Electric Company's handbook on receiving tubes, picture tubes, special-purpose tubes, and germanium diodes has been made available. The 192-page book (*ETR-15F*) gives the characteristics of approximately 2,000 tube types of which over 150 are new. Other new features include a classification chart on receiving tubes which permits selecting a tube by the type of application; characteristic curves of representative types; a thumb index; and a table of con-

(*Continued on page 50A*)

You can cut costs...improve design...simplify purchasing with C-D-F DIAMOND® VULCANIZED FIBRE

If your job is to select a general-purpose insulating material that is low cost, useful for both electrical and mechanical applications, easy to machine and form, consider the advantages of a unique old-timer — C-D-F's Diamond Vulcanized Fibre. C-D-F first made fibre in 1895, back in the early days of the electrical industry, and is today one of the world's largest producers and developers of this versatile material.

OUTSTANDING MECHANICAL QUALITIES

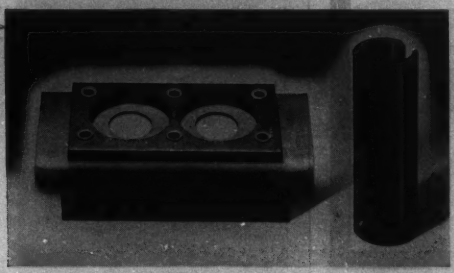
Think what Diamond Fibre can do. Its weight is half that of aluminum, yet it is one of the strongest materials known per unit weight. Tensile strength is 10,000 to 15,000 pounds per square inch. Shearing strength is about 10,000 pounds. Almost as strong as iron, on a weight:strength ratio basis. Diamond Fibre is tough and will not readily crack or shatter under heavy impacts. Its surface is hard and smooth. In forming, fibre can be moistened and dried repeatedly without having its structure, or quality significantly altered. C-D-F makes a special *forming* fibre, using *longer* cotton cellulosic fibers for added strength.

ALSO GOOD ELECTRICALLY

Although given a modest insulation rating for resistance to heat (A.I.E.E. Class A with a temperature limit of 221°F.), Diamond Fibre is often used because of its excellent arc resistance and good dielectric strength. It also has desirable deionizing properties and low heat conductivity. Fibre can be combined or surrounded with moisture-resistant laminated plastic. C-D-F does this in volume for manufacturers of low voltage cartridge fuses and high tension expulsion fuses. Inside is a fibre tube with excellent arc extinguishing properties and high internal bursting strength. Outside is a weather- and moisture-proof shield of rolled phenolic Dilecto.

MANY GRADES AND FORMS

Diamond Fibre sheet and roll grades include Bone, Commercial, and Electrical Insulation (fish paper) NEMA grades. Fibre tubing is normally made only in Bone grade, with rods available in both Bone and Commercial grades. The chart shown outlines the major characteristics of these grades. Special grades include fibre specifically adapted for these mechanical purposes: abrasive, bobbin, flexible, forming, pattern, shuttle, sanitary goods, trunk and case. Built-up sheets can be supplied that are lower in cost than standardard thick sheets.



GOOD EXAMPLES of Diamond Fibre formed and machined by C-D-F. *Left*—An insulating barrier made from three pieces of fibre, punched and formed. Fibre tubing is even used for rivets. *Right*—A fibre tube which has been smooth-sawed to length, punched twice and countersunk. C-D-F can handle the entire job for you, do it faster and at low cost. This includes selecting and testing the proper grade of fibre, machining and inspection, assembling if needed.

C-D-F BONE FIBRE	Hard, stiffest grade. High density. Resists wear, abrasion, has high compressive strength. Good dielectric strength when dry. Super machining qualities. Not recommended for bending.
C-D-F COMMERCIAL FIBRE	Mechanical and electrical grade. Medium density. Tough, pliable. Good mechanical properties. Fair dielectric strength, normally high when dry. Can be bent, punched, and formed.
C-D-F DIAMOND INSULATION	Electrical insulation "fish paper" grade. Unusually free from foreign matter. Withstands extreme bending and forming without cracking. High dielectric strength, except under high humidity.

WHAT IS FIBRE?

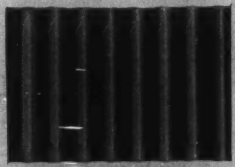
Vulcanized fibre is made by combining layers of chemically jelled paper. The chemical compound used in gelling the paper is subsequently removed by leaching and the resulting product, after being dried and finished by calendering, is a dense material of partially regenerated cellulose in which the fibrous structure is retained in varying degrees, depending upon the grade of fibre.
—NEMA Standard VU 1-1.1

VULCOID—A RESIN-IMPREGNATED FIBRE

One of C-D-F's products is a great material called Vulcoid. Vulcanized Fibre is its base, but a special combination of C-D-F resins give Vulcoid a moisture resistance intermediate between vulcanized fibre and that of higher-cost laminated thermosetting plastic. One company uses Vulcoid for electric light switch parts where it cuts their costs and improves their products. Another big outfit uses Vulcoid in place of fibre for its improved electrical properties and good formability. If you have never tested or heard of this C-D-F exclusive, write for details and samples.

MANY LESSONS IN FIBRE KNOW-HOW

At C-D-F there are bins holding thousands of sample Diamond Fibre parts — for electrical, textile, materials-handling, and machinery applications. They represent years of experience in designing and machining fibre to meet exacting needs. Also, they stand for C-D-F's ability to help you solve your specific materials selection problem. Get the facts about C-D-F and Diamond Fibre. Call your nearest C-D-F sales engineer (offices in principal cities), or look in Sweet's Product Design File. Write for samples and the new 1955 Diamond Fibre catalog with complete mechanical and electrical properties, size charts. Enclose your print for quotation—C-D-F is a big, reliable source of supply!



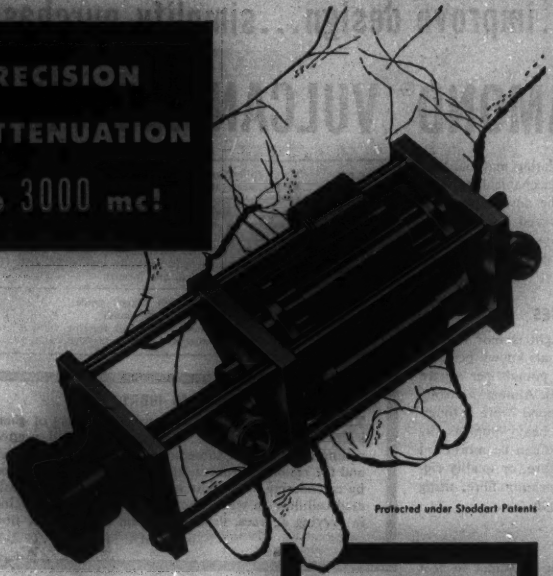
C-D-F CORRUGATED FIBRE is used by manufacturers of distribution transformers for load and oil ducts. The corrugations do not flatten out after baking or in oil at temperatures normal to such units. Also, it is more economical than laminated molded thermoplastic and can be cut to size, with a big saving in time and materials.

WRITE FOR NEW DIAMOND FIBRE CATALOG!

C-D-F Continental-Diamond Fibre

CONTINENTAL-DIAMOND FIBRE COMPANY
NEWARK 98, DELAWARE

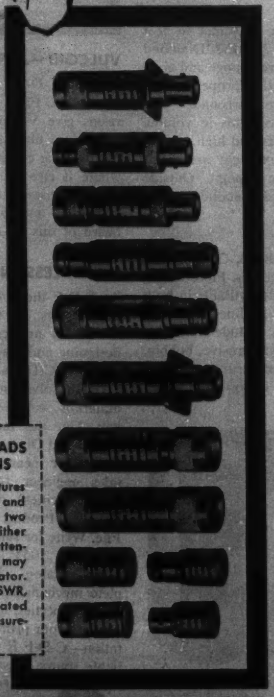
PRECISION ATTENUATION to 3000 mc!



Protected under Stoddart Patents

six-position
TURRET ATTENUATOR
featuring PULL-TURN-PUSH *action*

FREQUENCY RANGE: dc to 3000 mc.
CHARACTERISTIC IMPEDANCE: 50 ohms.
CONNECTORS: Type "N" Coaxial female fittings each end.
AVAILABLE ATTENUATION: Any value from 1 db to 60 db.
VSWR: 1.2 max., dc to 3000 mc/s, values from 10 to 60 db. As value decreases below 10 db, VSWR increases to not over 1.5.
ACCURACY: ± 0.5 db.
POWER RATING: One watt sine wave power dissipation.



SINGLE "IN-THE-LINE" ATTENUATOR PADS and 50 ohm COAXIAL TERMINATIONS

This new group of pads and terminations features the popular Type C and Type N connectors, and permits any conceivable combination of the two styles. For example, the two connector types, either male or female, can be mounted on the same attenuator pad, with or without flanges, so that it may serve as an adapter as well as an attenuator. Frequency range, impedance, attenuation, VSWR, accuracy and power rating are as designated above. Send for free bulletin entitled "Measurement of RF Attenuation."

STODDART AIRCRAFT RADIO Co., Inc.
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(*Continued from page 44A*)

tents. This new edition may be obtained from General Electric tube distributors.

Power-Line Carrier Equipment. The complete line of Westinghouse power-line carrier equipment (type *FD*) for voice communications is described in a new 24-page booklet available from the company. Some features of type *FD* equipment described are improved receiver selectivity, operation from station batteries, filament current regulation, and accessibility of assemblies. Use of carrier for manual simplex, duplex, and automatic simplex voice communications is discussed. For a copy of this bulletin, *84-400*, write Westinghouse Electric Corporation, Post Office Box 2099, Pittsburgh 30, Pa.

Multiple-Pressure Readout Systems. Multiple-pressure readout systems to speed up data handling for process industries, wind tunnels, engine test facilities, and marine model basins are illustrated in a new 12-page catalogue. These packaged systems utilize a single high-accuracy sensing device and pressure comparators to sample up to 200 pressures simultaneously with accuracy of 1 part in 2,000. Operation, applications, and performance characteristics are illustrated with photographs, dimension drawings, and schematic diagrams. Catalogue *58-15* is available on request from Fischer and Porter Company, 393 Jacksonville Road, Hatboro, Pa.

Vulcanized Fiber and Laminated Plastic. "Engineering Materials for Modern Industry" is the title of a 16-page 2-color bulletin published by National Vulcanized Fibre Company, covering the properties, grades, and uses of National vulcanized fiber and Phenolite laminated plastic. Case studies match physical properties to typical uses for both of these materials. Tables list the general properties of the several grades of National vulcanized fiber and the 40 grades of Phenolite laminated plastic. Copies of this bulletin are available without charge from National Vulcanized Fibre Company, 1055 Beech Street, Wilmington 99, Del., or National Fibre Company of Canada, Ltd., 107 Atlantic Avenue, Toronto, Ont., Canada.

Electrical Measurement. Baldwin *SR-4* load cells and load beams for electrical measurement of weight and force are presented in a 20-page bulletin no. *4301* by Baldwin - Lima - Hamilton Corporation, Philadelphia 42, Pa. Principles of measurement, specifications of load-sensitive devices, available instrumentation, and typical applications are included in the bulletin.

Nuclear Reactor Controls. "Control Systems for Nuclear Reactors," published by Leeds and Northrup Company, outlines the design, instrumentation, and fabrica-

(*Continued on page 52A*)

International Rectifier Corporation

proudly presents

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germanium power rectifiers!

This new line of Power Rectifiers features

- High efficiency ... up to 97%
- Lowest forward drop
- High reverse to forward ratio
- No reforming required after storage
- Unlimited life expectancy
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  26 to 66 AC input volts per junction
  150 to 100,000 amps DC output

Operating temperature range
55° C to + 75° C

International Rectifier

(*Continued from page 50A*)

tion of complete "package" control systems for operation of any type of research or power reactor. The 8-page brochure explains the control channels which comprise a reactor control system, and discusses the various services offered by the company as a part of their "package" concept of control system engineering. Request Folder *ND46-70-700(1)* from Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pa.

Liquid Level Bulletin. A 26-page bulletin describing the complete line of liquid level gauges for indicating, recording, controlling, and telemetering has been released by The Bristol Company. The bulletin shows float-type, pressure-type, differential pressure-type, and bubbler-type liquid and water level gauges, in strip and round-chart models. Air or electric controllers are available in several modes. Engineering data on the choice of the proper bulb and instrument for a given installation are presented, as well as installation information on liquid level telemetering and remote control. Copies of bulletin *L701* are available on request from The Bristol Company, Waterbury 20, Conn.

Varistors. Comprehensive data on applications, characteristics, current ratings, enclosures, terminations, etc., of these asymmetric nonlinear resistors are given in catalogue data bulletin *SR-3*. Write to International Resistance Company, 401 North Broad Street, Philadelphia 8, Pa.

Quick Reference Instrument Catalogue. A "Quick Reference Instrument Catalogue" which lists the salient points of Du Mont cathode-ray oscillographs and accessory instruments is available from the Technical Sales Department, Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Avenue, Clifton, N. J. The 8-page catalogue is divided into three sections devoted to low-frequency instruments, high-frequency instruments, and accessory instruments. A picture of each instrument is provided together with a brief description of its features and some of the fields in which it has applications. Additional technical information is provided in tabular form in each of the catalogue's three sections.

Inductronic System for Measurement and Control. A new catalogue illustrating and describing the Weston Inductronic system for measurement and control has been issued by the Weston Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, N. J. The catalogue gives technical information, as well as application data, on the basic Weston Inductronic d-c amplifying unit as well as on its companion models such as multirange d-c amplifiers, sensitizing amplifiers, integrating fluxmeters, limit and knife-edge control units, and product resolvers. Copies of this catalogue are available by writing direct to the manufacturer.

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